POWER PLANT ENGINEERING

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Parkersburg Station, Monongahela Valley Traction Co.

SERVING A LARGE INDUSTRIAL AND ELECTRIC RAILWAY DISTRICT. CONDENSER PIT PROVIDED IN WHICH CIRCULATING SYSTEM OPERATES AS A SYPHON

ONE OF THE MOST modern power stations operating in West Virginia is that of the Monongahela Traction Co., located on the Ohio River, near Parkersburg. It was completed in April, 1916, and at present has a capacity of 5000 kw., but will ultimately have double that rating. Approximately 40 per cent of its output is used by the electric railway, which operates between Parkersburg, W. Va., and Marietta, Ohio, and also the local traction lines in both cities and the interurban extending up the Muskingum River to Beverly, Ohio.

In designing this plant, ample provisions were made to safeguard against the severe floods to which the Ohio River is subject. The turbine room floor is 5 ft. above the highest known stage of the river, and the station concrete foundation, 30 ft. in height, varies from 24 to 72 in. in thickness. Construction of the station and the relative arrangement of units are shown in the cross-section view, Fig. 2.

SPACE PROVIDED FOR DUPLICATE BOILER UNITS

PRESENT steaming capacity is supplied from four 440 hp. water-tube boilers, constructed to operate at 200 lb. pressure and give 135 deg. superheat. They are equipped with soot blowers and steam flow meters.

Each boiler is fired by an automatic stoker of the Dutch-oven type and approximately 3.5 lb. of fuel is burned per boiler hp.-hr. The coal is mine run, with a heat value of 1250 B.t.u., mined at the company's mines

FIG. 1. TURBO-GENERATORS AT PARKERSBURG

near Fairmont. Approximately 50 tons are burned daily.

Coal is delivered on the siding shown in Fig. 5, dropped through a receiving hopper to an inclined belt conveyor carrying it into a two-roll crusher, after which it is elevated to the 600-ton steel bunker by a bucket conveyor, and delivered to a distributing belt conveyor. Two 15-hp. motors operating these conveyors are operated from the boiler room floor, and are so arranged electrically that a stoppage of the elevating and distributing motor automatically stops the crusher and incline belt motor, thus preventing clogging or jamming of the elevator. The equipment has a capacity of 50 tons per hour. All coal is passed into a traveling weight hopper before delivery to the furnaces. From hoppers equipped with sliding gates, ashes are dropped into buggies and utilized for filling in about the premises.

One side of the boiler room remains as space for future boilers, and in accordance with modern designs, an unusually large window area is provided.

Products of combustion are carried to a 215-ft. stack, 132 in. in diameter, through a steel breeching with 1½-in. asbestos covering outside of a ½-in. dead-air space.

Feed water is drawn from a 6000-hp. open feed water heater and V-notch metter placed just above and between the two batteries of boilers. Steam from the turbine auxiliaries is delivered to the heater direct. A 200-hp. closed heater is also provided, all condensate water passing through this heater before entering the large heater. Makeup water is supplied through an automatic float valve from a steel service tank on the roof. Below the heater are two turbine driven centrifugal feed pumps delivering 250 g.p.m. at 3200 r.p.m. Water for boilers and circulating purposes is drawn from the city water system, except in the summer months when the river water is suitable.

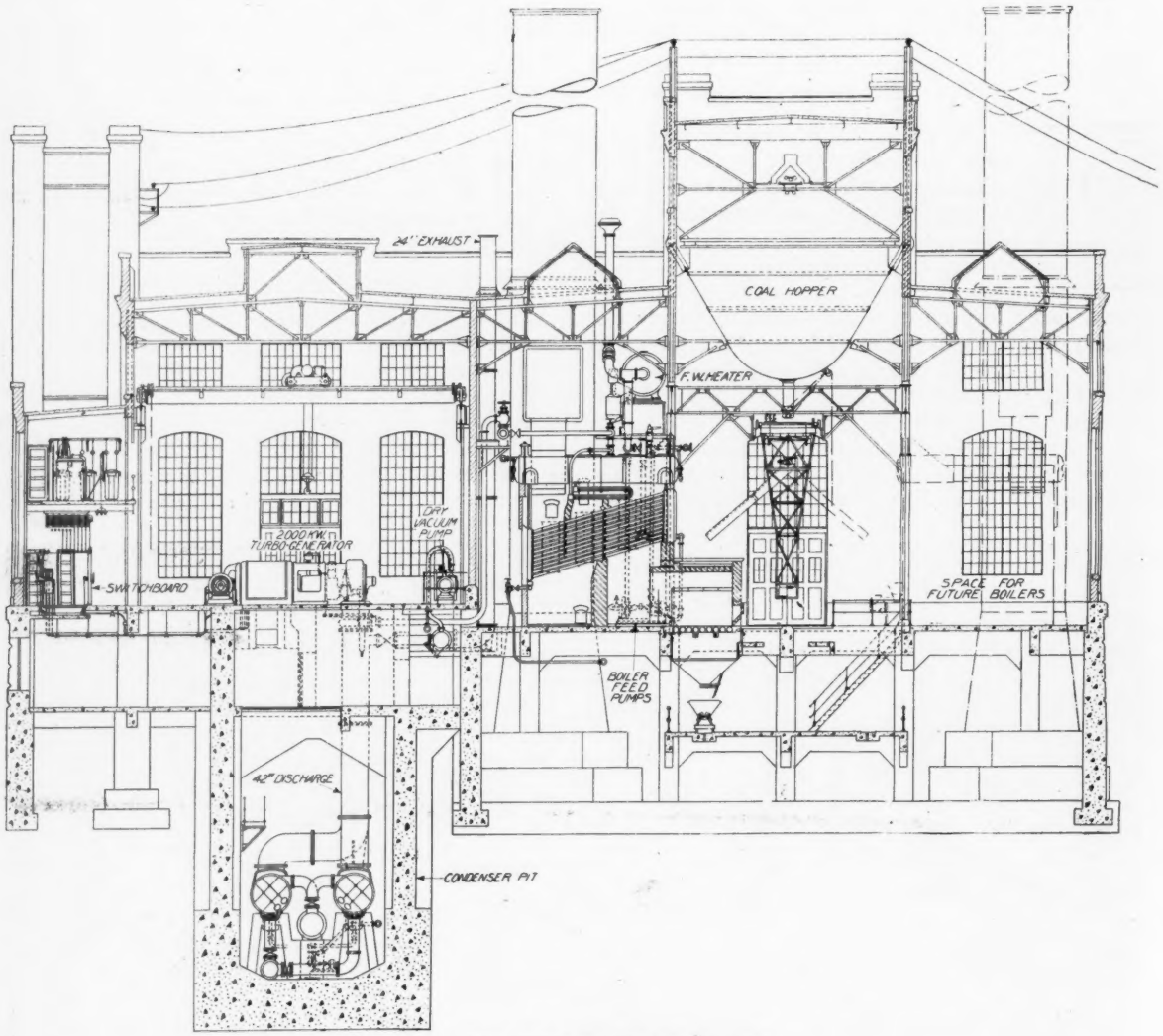


FIG. 2. CROSS-SECTION VIEW OF STATION

Three Turbo-Generators and Three Railway Sets Provided for Present Demand

Two 2000-kw. and one 1000-kw. turbo-generators supply the present current demands. Ultimately a 5000-kw. unit will be added. These units generate current

at 2300 v., 60-cycle, and 3-phase, for Parkersburg distribution. For transmission to Marietta, it is stepped up through either of a duplicate set of transformers to 23,000 v. and delivered over the towers shown in Fig. 5 to the main line, about a mile distant, which follows the electric railway.

This tower line traverses a low section of ground subjected to floods of the river, and consists of seven line towers, two anchor towers and two angle towers. Their heights above the ground range from 55 to 63 ft., and all are set on heavy concrete foundations. They

induction motor. As previously mentioned, about 40 per cent of the current produced is utilized by the electric railway, the balance being sold for light and power to neighboring municipalities and factories. Two of the three motor-generator railway sets are shown in Fig. 4. Each is operated by a 700-kv.a., 2300-v. synchronous motor at 900 r.p.m., delivering 650-v. current. These machines are provided with a starting device at each end; the starting may be effected at the d.c. end should the a.c. starting device be out of commission, or vice versa.

From the turbines steam is exhausted to counter-cur-

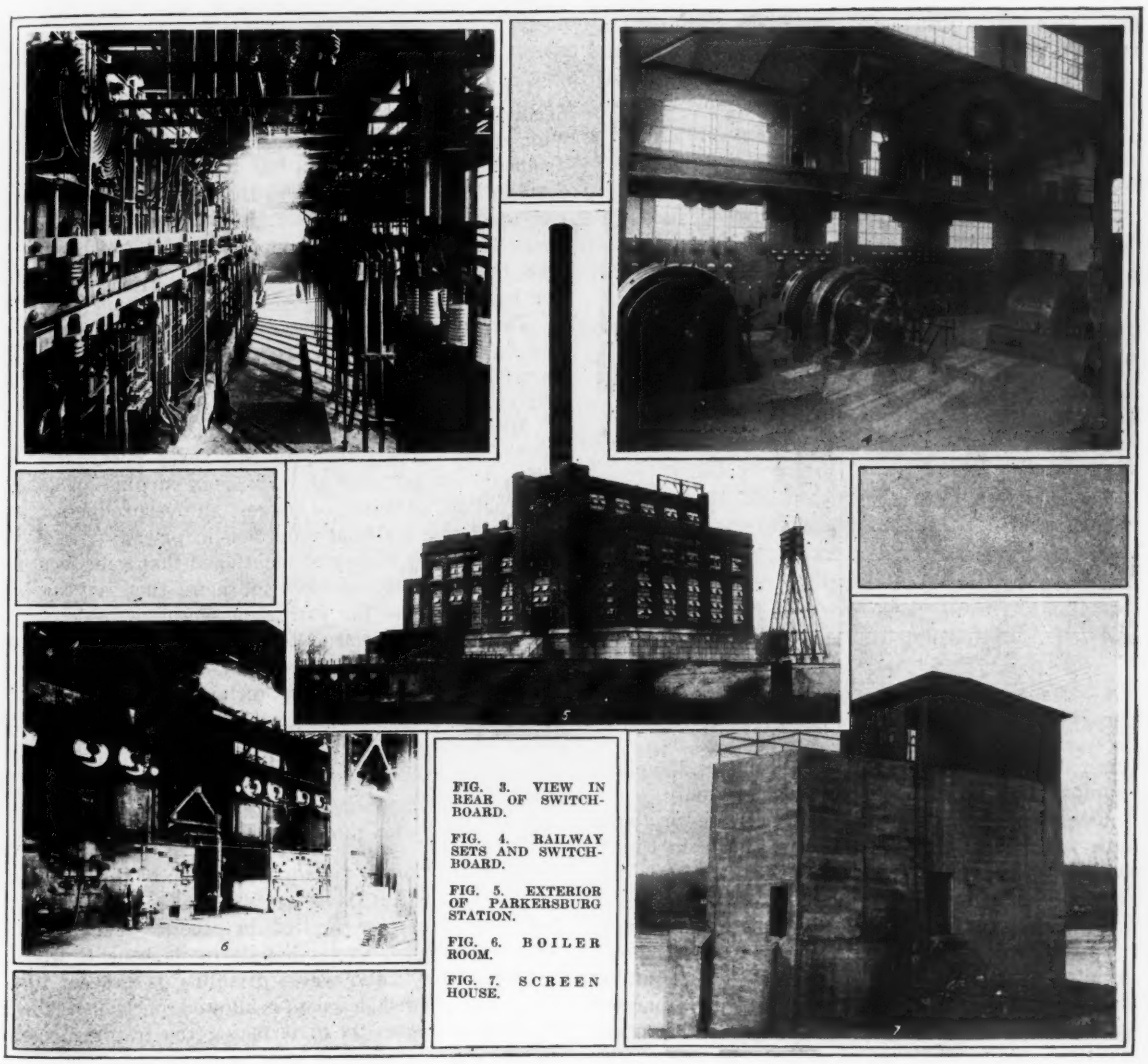


FIG. 3. VIEW IN REAR OF SWITCHBOARD.

FIG. 4. RAILWAY SETS AND SWITCHBOARD.

FIG. 5. EXTERIOR OF PARKERSBURG STATION.

FIG. 6. BOILER ROOM.

FIG. 7. SCREEN HOUSE.

were designed to carry two 3-phase high tension circuits, six commercial feeder circuits, four railway feeder circuits, and two messenger ground wires.

Type of switchboard, the location of regulators and view of busbar arrangements are shown in Figs. 1 and 2. Main feed panels employ two 250-v., 60-amp. lever switches, hand operated. In the outgoing transformer bank, 15,000-v., 300-amp. automatic oil switches, hand operated ,and one 22,000-v., 300-amp. solenoid-operated switch are provided.

Exciting current is furnished by either of two 75-kw. sets, one turbine driven, the other operated by a 115-hp.

rent surface condensers through 42-in. and 36-in. lines, or delivered in part to a common 24-in. free exhaust line. Two of the three condensers have 4200 sq. ft. of effective surface, the third one contains 2140 sq. ft. All condensers and most of the auxiliary pumps are located in a concrete pit, as shown in Fig. 2, the floor of which is 38 ft. below the turbine room, and having a 6-ft. concrete base.

Intake and Circulating System

Above certain stages the Ohio River carries a large amount of trash which rapidly clogs any of the ordinary

types of intake screens and pumps. Studies determined the fact that up to a 10-ft. stage, water could be drawn from the river through an ordinary, properly screened intake without difficulty, but at higher stages any suction opening would quickly be closed up. At Parkersburg, the level seldom falls below 10 ft., as a dam just below the city maintains this level for navigation.

To overcome this situation, a double line of 36-in. cast iron pipe from the river was divided just outside of the building into four lines by means of a "Y" connection, as shown in Fig. 8. By means of eight motor-controlled valves, either line may be used as a suction or discharge, and the flow may be reversed through the condensers. Four of these valves just inside the building control the reversal of the suction and discharge lines, and four located beyond the circulating pumps control the reversal through the condensers. Master switches operate each set of four valves simultaneously.

As the center line of the discharge opening of the condensers is located 28 ft. above the low water stage of

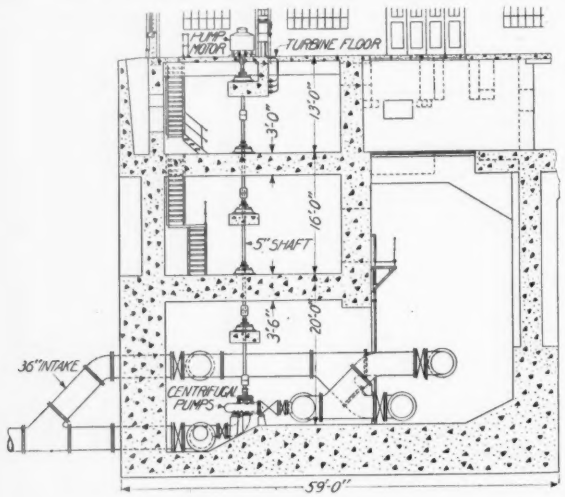


FIG. 8. ARRANGEMENT OF CIRCULATION LINES

the river, the entire circulating system acts as a syphon, the pumps operating against a friction head only.

Under average conditions, with 10 ft. stages or above, water is taken in at river screen house shown in Fig. 7. It passes through a set of rack bars spaced on 2½-in. centers and then through a ½-in. mesh revolving screen, or through a stationary screen of ½-in. mesh installed in the compartment for a future rotating screen.

Available for low water stages are two 36-in. intakes extending out into the river and are properly separated to prevent short circuiting. Under any condition, one pipe or the other is employed as a discharge line. Their openings are protected by large wooden wells, properly screened to keep out large sticks and heavy trash.

Mounted on the turbine room floor are the induction motors which drove three centrifugal vertical volute circulating pumps by means of shaft connections. Two of these pumps are 16 in., driven by 60-hp. motors through a 4-in. shaft, and at 400 r.p.m. delivering 6000 g.p.m. against a 19-ft. head. Driven at 574 r.p.m. by a 25-hp. motor, the third pump, a 10-in. volute type, delivers 2000 g.p.m. The vertical shafts and pump impellers are supported on one thrust bearing which is located below the motor. Self-alining shaft bearings are provided at 12-ft. intervals.

Below each condenser is a 2½-in. motor-driven condensate pump, delivering 80 g.p.m. at 1740 r.p.m. against a head of 115 ft. and a 6 by 7½ by 6-in. duplex pump. Also located in this condenser pit is a 14 by 8 by 12-in. duplex plunger fire pump, a 7½ by 5 by 10-in. piston pump for general use, a 5 by 12 by 10-in. wet vacuum pump and a 6 by 5¾ by 6-in. reserve, and a motor-driven centrifugal sump pump.

Three dry vacuum pumps are located in the turbine room; two 8 by 20 by 12-in. and one 6 by 14 by 10-in. pumps.

Decline in Fuel Oil Prices

ONLY SLIGHT MENTION has been made of the heavy decline that has taken place in the price of crude petroleum used for fuel purposes. Since the signing of the armistice the falling off in the war demand for fuel has resulted in a decline of more than 50 per cent in Mexican and Texas fuel oils. Last November the price of fuel oil was $2.26 a barrel as sold to the world's navies. Now the price to large users of fuel oil is less than $1 per barrel.

The Mexican Petroleum Co., the largest producer of fuel oil, reports that its exports for April were 529,685 barrels, compared with 1,979,522 barrels in December of last year and 1,122,295 barrels in January, 1919.

Meanwhile there has been a considerable increase in production of petroleum in the Texas pool. But statistics do not yet show an increase in surplus stocks, outside fuel oil, sufficient to suggest an overproduction that may lead to a material reduction in prices.

Incidentally it may be mentioned that some local and New York capitalists have for more than a year been testing a process for extracting gasoline, which, after many trials, is declared to be better than the Burton process. This latest process will, it is declared, handle even heavy Mexican oils, reclaiming from them an amount of gasoline sufficient to add materially to the value of the crude product. The company has an experimental plant at Kansas City which is being successfully operated.

THE LATITUDE allowed the Federal Board for Vocational Education in the administration of the Vocational Rehabilitation Act, is as broad in some of its phases as the restrictions are limited in others. The law only allows those men to participate in its benefits who are "compensable," and whose disability is at least 10 per cent. But the disabled man is allowed much liberty in his decision in regard to undertaking the training courses. It has been the natural impulse of these soldiers to get back to work as quickly as possible. Many, seeing no benefit in wasting time at some training school, have taken the first job offered, and often in a short while have been forced to give it up, realizing that their strength was not sufficient to "carry on." This experience, though unfortunate, need not be discouraging. The offer of the government is still open to such men, and many are finding it to their advantage to come back and get the preparation which they need. The Board is particularly anxious to have the assistance of the public in making this opportunity known.

FUEL CONSERVATION LETTERS

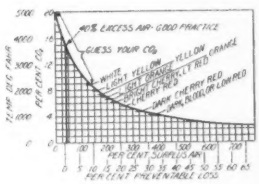
By Joseph Harrington, Formerly Administrative Engineer for the State of Illinois

Analysis of Flue Gases. Letter No. 12

THE SOLE object of this letter is to press home just one point—testing for CO_2 can and should be practiced in every boiler plant.

Your boiler room is nothing more or less than a manufacturing laboratory, and CO_2 is the primary product.

The oxidation of coal-forming carbon dioxide, results in the production of heat. This is really a by-product or incidental accompaniment of the chemical reaction. It is, however, the thing that we use. Obviously the efficiency of the reaction is measured by the amount of CO_2 that is made, so that you can keep a close check on your conditions by the analysis of the flue gases for this constituent. Without doubt, the amount of CO_2 in the flue gases is the best single index of furnace efficiency. It shows the fireman how well or how poorly he is managing his fires; how much of the expensive heat in the coal is being wasted through ignorance or carelessness. A fireman who can be depended upon to read a steam gage or pressure gage, can test CO_2 and use the indications thus obtained in his work of furnace control. Surely, if he cannot or will not do this, he is the most expensive luxury for his employer and for the nation.



Coal is the most valuable commodity handled by man, and in the boiler room laboratories of the nation, must be handled with the same nicety and care with which other materials are handled that enter into the finished product of the manufacturers.

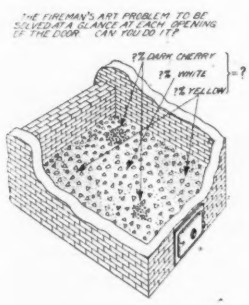
Give your engineer an opportunity to show what he can do in this respect. Let the engineer regularly test for CO_2, entering these results in the station log and studying their effect on the general efficiency. You will be surprised at the result.

There is a limit, however, to the amount of CO_2 that should be produced. Not always does the highest percentage of CO_2 correspond to the highest general efficiency.

CO_2 is the product of complete combustion, and this necessitates a sufficiently large furnace and a sufficiently good admixture of air with the furnace gases to complete the reaction. A small furnace, therefore, must be supplied with more air per pound of coal than a large furnace, for the simple reason that oxidation must take place more rapidly; and this can only be effected when there is an abundance of oxygen present.

The losses by unburned gases may be greater than the loss due to the excess air. I have seen instances wherein 9 per cent CO_2 gave a better result than 12 per cent; but when the furnace conditions are right, CO_2 may be carried to 15 per cent without a detrimental effect.

With high volatile coals, it is only possible to get about 19 per cent; so that 15 per cent represents very nearly commercial perfection. It would take an extraordinary set of furnace conditions to permit carrying the percentage much higher.



Let your engineer, therefore, study his furnace conditions, and by using the coal weights and the amount of steam produced, determine where the general efficiency is best. This will vary in different furnaces and with different kinds of coal; so that a careful study must be made to determine the percentage in each instance. With any given plant, however, this can readily be done; and once established it then becomes the function of the gas analyzer to indicate how nearly your firemen are adhering to the established standard.

The analysis of the flue gases is the best single index of this efficiency, and it has fortunately been perfected to a degree where the instruments for obtaining it are reliable and substantial. You had better not have any instrument, however, than an inaccurate one or one not in use. Rather than have you buy a recording instrument and then let it stand idle, I would see you purchase a hand analyzer and then insist upon a daily analysis. Your engineer's log sheet, if properly filled out, will give you this result day by day.

In thousands of plants through the country, flue gas analysis is, and has been for a long time, used to control combustion and improve economy. It is a thoroughly well tried practice. If your plant is not among that number, they are ahead of you in progressiveness. Cost of coal and other factors equal, they get their steam cheaper than you do.

Interconnection of California Power Systems

DIVIDED INTO TWO GROUPS OF CONNECTED LINES, LARGE SAVINGS ARE SECURED IN FUEL AND WATER SUPPLY AND DIVERSITY FACTORS IMPROVED. BY P. M. DOWNING*

AN increasing shortage of power, due in part to the retardation of hydro-electric development because of unfavorable legislation, coupled with the recent rapidly increasing demand for power, which demand was abnormally increased due to the exigencies of the war, made necessary a comprehensive study of the power situation in California. This was undertaken with the idea of first meeting the immediate and imperative demand with the facilities already at hand, and, second, the laying out of a systematic plan for future development. This later phase is covered in a report made by Maj. Geo. F. Sever of the War Industries Board.

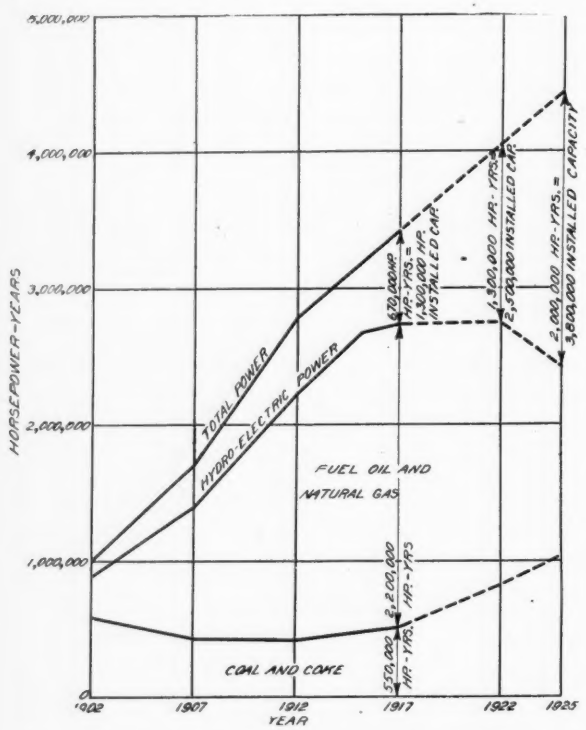


FIG. 1. CHART SHOWING POWER DEMANDS OF PACIFIC COAST STATES

Owing to the abnormally low rainfall during the 1917-18 season, which seriously curtailed the output of the hydro-electric plants, the situation became still more serious because it involved the necessity of supplanting the hydro shortage by the use of additional steam power requiring the increased use of fuel oil at the very time when it was absolutely essential that fuel oil be conserved for war purposes.

Figure 1 is a chart developed by D. M. Folsom, Pacific Coast Fuel Oil Administrator, showing that in seven years' time the capacity in hydro-electric power must be doubled to meet the demand in the Pacific coast states.

Initiated by the Railroad Commission of California was a review of the problem, entitled "In the matter of the construction and operation of the utilities during the emergency created by the war." Two committees were appointed, one for Southern California and one for Central and Northern California. The companies included in the southern group were the Los Angeles Gas & Electric Co., Los Angeles Aqueduct, Southern California Edison Co., San Joaquin Light and Power Corp., Mt. Whitney Power & Light Co., Southern Sierras Power Co. and San Diego Gas & Electric Co.

These companies as a group were not so much involved in an actual immediate shortage of power, but were more concerned with the conservation of fuel oil. The rivers of Southern California are of an extremely variable flow. For this reason a great portion of their runoff is lost as flood water. Good storage sites exist north of the Tehachapi River, but further south good reservoir locations are comparatively few. The interchange of energy between the Southern California Edison Co. and the San Joaquin Light & Power Corporation illustrates the fact that storage capacities become doubly useful when two systems are interconnected, permitting the stream flow plants to carry the load during periods when advantage may be taken of the storage facilities on a different water shed. Advantage is taken in the same manner of the storage facilities of the Los Angeles Aqueduct System, where water is being conserved during the early morning hours while the load is being carried by the stream flow plants on the Kern River.

Much is accomplished toward saving fuel oil through interconnection which permits advantage being taken of the diversity of loads between systems supplying different classes of business. A striking example of this diversity is seen in the San Joaquin Light & Power Corporation's load, which is mainly due to summer pumping, while the peak load of the Southern California Edison Co. occurs in November. Therefore the San Joaquin plants carry a considerable part of the Southern California Edison's load in the winter time, while the reverse is true in the summer time, resulting in a material reduction in the use of steam reserve plants.

From a study made in 1917 of the diversity factors in the Southern California group, we find that out of a possible maximum peak of 220,000 kw. there existed a total diversity of about 15,000 kw. This is worth to the companies concerned approximately $1,000,000, provided full utilization could be made of it.

Certain limitations and decreases in economies occur in interconnection, due to the fact that each individual company developed as an entity within itself without thought of the future possibility of amalgamating into one single operating unit. The Southern California Edison and the Los Angeles Co. operate at 50 cycles, while all of the others operate at 60 cycles, and interconnection is accomplished through frequency changers or the speed of the generators is changed to conform with the frequency of the systems being supplied. A power house may be operating one or more generators at a changed

* Chief Engineer Pacific Gas & Electric Co.

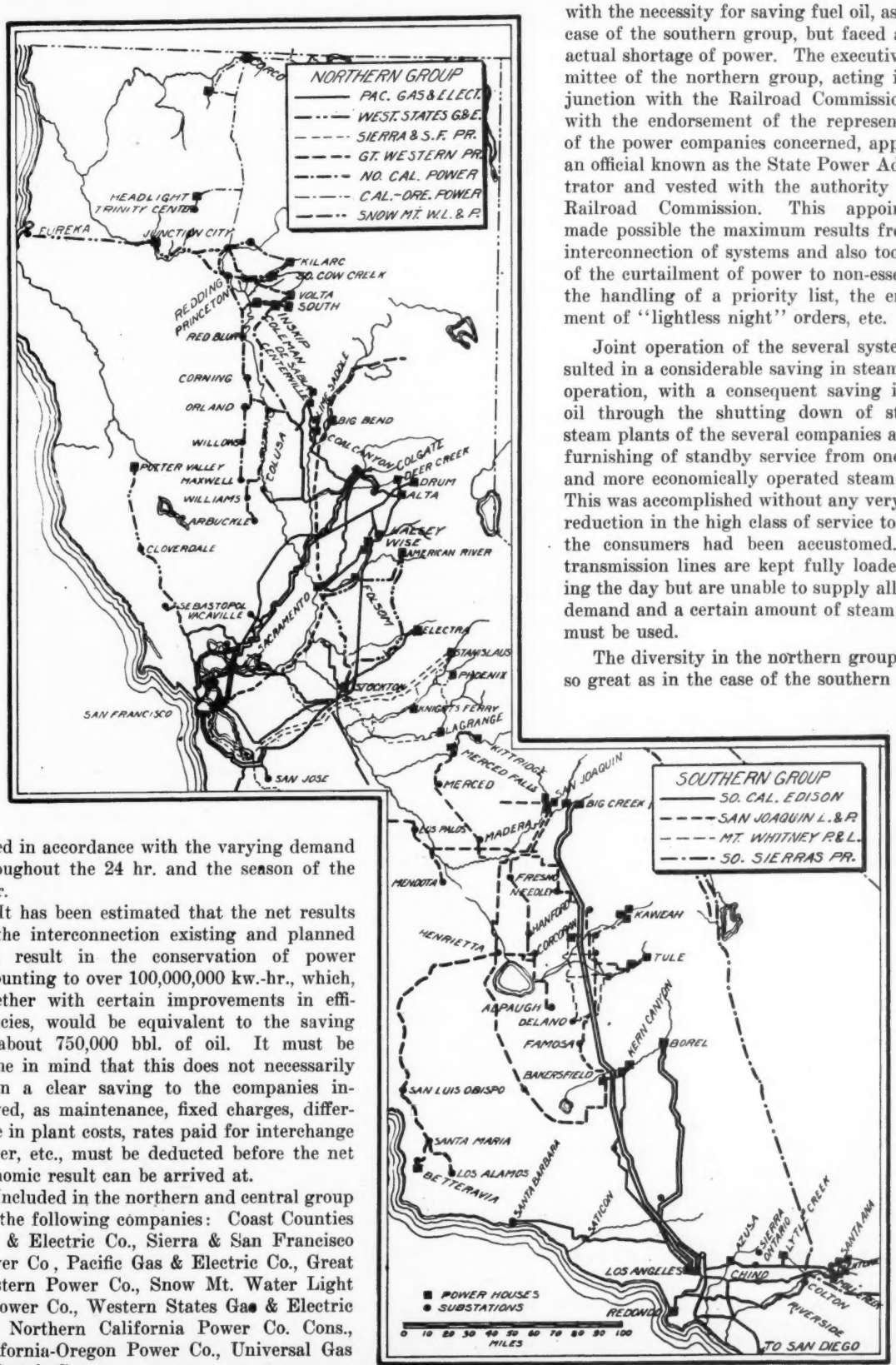


FIG. 2. INTERCONNECTING LINES OF THE TWO SYSTEM GROUPS

speed in accordance with the varying demand throughout the 24 hr. and the season of the year.

It has been estimated that the net results of the interconnection existing and planned will result in the conservation of power amounting to over 100,000,000 kw.-hr., which, together with certain improvements in efficiencies, would be equivalent to the saving of about 750,000 bbl. of oil. It must be borne in mind that this does not necessarily mean a clear saving to the companies involved, as maintenance, fixed charges, difference in plant costs, rates paid for interchange power, etc., must be deducted before the net economic result can be arrived at.

Included in the northern and central group are the following companies: Coast Counties Gas & Electric Co., Sierra & San Francisco Power Co, Pacific Gas & Electric Co., Great Western Power Co., Snow Mt. Water Light & Power Co., Western States Gas & Electric Co., Northern California Power Co. Cons., California-Oregon Power Co., Universal Gas & Electric Co.

In this group the power companies and their subsidiaries were not only confronted with the necessity for saving fuel oil, as in the case of the southern group, but faced also an actual shortage of power. The executive committee of the northern group, acting in conjunction with the Railroad Commission and with the endorsement of the representatives of the power companies concerned, appointed an official known as the State Power Administrator and vested with the authority of the Railroad Commission. This appointment made possible the maximum results from the interconnection of systems and also took care of the curtailment of power to non-essentials, the handling of a priority list, the enforcement of "lightless night" orders, etc.

Joint operation of the several systems resulted in a considerable saving in steam plant operation, with a consequent saving in fuel oil through the shutting down of standby steam plants of the several companies and the furnishing of standby service from one large and more economically operated steam plant. This was accomplished without any very great reduction in the high class of service to which the consumers had been accustomed. The transmission lines are kept fully loaded during the day but are unable to supply all of the demand and a certain amount of steam power must be used.

The diversity in the northern group is not so great as in the case of the southern group,

with the possible exception of the Sierre and San Francisco Power Co. load, the bulk of whose output is purely a street railway load, and full advantage of this fact is taken.

All of the plants in this group operate at 60 cycles, and no particular difficulty is experienced in operating the entire network as a unit, the governing being taken care of by one large plant with the load on the other plants blocked out and the governors set sluggish or to operate above or below a pre-determined speed.

One of the situations, the interconnecting two systems, which is apt to give trouble, occurs when each system has considerable generating capacity and load of its own and the connecting line is of considerable length and small carrying capacity. In which event, if the connecting line be heavily overloaded, there is a decided tendency to pull out of synchronism. In case where lines are of unequal length and the impedance is widely different it may be necessary to avoid paralleling at more than one point. It is not essential that equal voltage be maintained in synchronizing two systems over long lines; in fact, a voltage difference of 10 or 15 per cent presents no great hazard. There will be a slight exchange of excitation which the higher voltage system will supply.

Given herewith are the existing interconnections and the amounts of power exchanged between the power companies operating in the northern and central groups:

1—Pacific Gas & Electric Co. and Great Western Power Co. at Oakland	5,000 kw.@ 11,000 v. 10,000 kw.@ 60,000 v.
2—Pacific Gas & Electric Co. and Sierra & San Francisco Power Co. in San Francisco:	
(a) Bay Shore—Martin	10,000 kw.@ 11,000 v.
(b) North Beach—Station F	15,000 kw.@ 11,000 v.
(c) Geneva—Martin	4,000 kw.@ 11,000 v.
3—Great Western Power Co. and Sierra & San Francisco Power Co., in San Francisco	9,000 kw.@ 11,000 v.
4—Pacific Gas & Electric Co. and Snow Mt. Water & Power Co. at Santa Rosa	5,000 kw.@ 60,000 v.
5—Great Western Power Co. and Snow Mt. Water & Power Co. at Santa Rosa	1,500 kw.@ 60,000 v.
6—Pacific Gas & Electric Co. and Western States Gas & Electric Co. at Folsom	3,000 kw.@ 60,000 v.
7—Great Western Power Co. and Western States Gas & Electric Co. at Folsom	1,000 kw.@ 22,000 v.
8—Sierra & San Francisco and Western States Gas & Electric Co. at Manteca	2,000 kw.@ 30,000 v.
9—Pacific Gas & Electric Co. and Western States Gas & Electric Co. at Stockton	3,750 kw.@ 2,200 v.
10—Sierra & San Francisco and City of San Francisco (Hetch Hetchy Development) at Priest's Hill	3,000 kw.@ 17,000 v.
11—Sierra & San Francisco and Utica Co. at Altaville	1,000 kw.@ 17,000 v.
12—Sierra & San Francisco and Coast Counties Gas & Electric Co. at San Juan (being installed)	3,000 kw.@ 24,000 v.
13—Coast Counties Gas & Electric Co. and Pacific Gas & Electric Co. at Morgan Hill	3,000 kw.@ 24,000 v.
14—Coast Counties Gas & Electric Co. and Pacific Gas & Electric Co. at Davenport	2,250 kw.@ 24,000 v.
15—Pacific Gas & Electric Co. and Northern California Co. at Chico	10,000 kw.@ 60,000 v.
16—Pacific Gas & Electric Co. and Northern California Power Co. at Solusa Corners (capacity now being doubled)	6,000 kw.@ 60,000 v.
17—Northern California Power Co. Cons. and California Oregon Power Co. at Kennet	10,000 kw.@ 60,000 v.
18—Northern California Power Co. and Western States Gas & Electric Co. at Junction City	3,000 kw.@ 60,000 v.
19—Pacific Gas & Electric Co. and North Western Pacific Ry. Co. at Alto	1,500 kw.@ 4,000 v.
20—Pacific Gas & Electric Co. and San Joaquin Light & Power Co. at Newman (future possibility; not now in service)	1,000 kw.@ 11,000 v.
21—Pacific Gas & Electric Co. and Sierra & San Francisco Power Co. at junction of lines Southern section of San Francisco Bay (future possibility; not now in service)	25,000 kw.@100,000 v.
22—Sierra & San Francisco Power Co. and Universal Gas & Electric Co. at San Francisco	2,500 kw.@ 11,000 v.

Some of these interconnections were in service prior to the advent of the Power Administrator and most of them are now in daily use.

The latest tie in connection involved the construction of a line between Castella and Kennet, about 25 mi., permitting the California-Oregon Power Co. to deliver surplus energy into the Northern California Power Company's system at Kennet, which in turn releases Northern California Energy for delivery through the Pacific Gas & Electric Co. system.

Operating in Northern California and Southern Oregon, the California-Oregon Co. have plants which are favorably located on streams with a remarkably constant flow throughout the year, and have never experienced a shortage of power. The full completion of this tie in connection requiring the additional reinforcement of certain tie lines and the building of step-up transforming station to connect to the Pacific Gas & Electric Co. system's 100-kv. line near Knights Landing, will provide a block of about 60,000,000 kw.-hr. annually for use in the great industrial centers about the Bay Districts.

Operating as if under one management, the combined systems of the northern group represent by far the largest interconnected system in the world, with an output for the year 1918 of 1,685,099,461 kw.-hr. and a maximum daily output July 16, 1918, of approximately 5,350,000 kw.-hr., serving approximately 48,000 sq. mi. of territory and over 2,100,000 population. The Southern California group follows as a close second.

It is interesting to note that there remain but four small gaps to complete a continuous tie in over 2000 mi. in length stretching from Harlowton, Mont., through the Pacific Coast states and down to the border of Mexico. This, of course, without regard to present economical limits of long distance transmission of electrical energy.

A RETURNED SOLDIER, whatever his disability and whether or not he has had previous experience, will, if he is at all interested in the subject of electricity, find some job that will be suitable for him, so great is the present demand for electrical men. It is not surprising that courses in electricity, either in construction, maintenance or repair, are popular with disabled soldiers who come to the Federal Board for training. There are at present 178 men taking courses in the general subject of electricity, 13 are studying bench work and 61 are preparing to be electrical engineers. Disabled men can fill many positions in power plants, such as switchboard operators, substation operators, combustion experts, attendants of auxiliary machinery, clerks, whose duty it is to analyze and record the daily operating charts and compile then into cost records are being used more and more in electrical plants.

Possibilities of Colloidal Fuel

METHODS OF PREPARATION, ITS CHARACTERISTICS AND OPERATION ECONOMIES

LARGELY THROUGH the investigations of its engineer, Lindon W. Bates, the Submarine Defense Association of New York evolved during the war a combination of oil and pulverized coal, which is termed colloidal fuel.

An interesting feature of the new development is that plants and railroads may buy from the manufacturers any grade of colloidal fuel they desire to the prescription wanted, or they may obtain the appropriate fixated oil and make a final composition themselves. No change in oil-storage or burning equipment is required. Another development is represented by colloidal fuel made with pressure-still residuals which hitherto have been quite neglected.

To make this practicable many months of laboratory research were required to discover a medium which would neutralize gravitation and keep the introduced heavier particles of carbon from settling, and calling for some special apparatus to mill the composite, so that each solid particle is surrounded by a film of liquid hydro-carbon. The new agent is a paste-like greasy substance, called "fixateur." Twenty pounds of this in a ton of liquid fuel keeps the powdered coal and tar suspended in the oil and evenly distributed throughout its volume.

Experiments in making colloidal fuel were conducted at sea on the U.S.S. Gem, a naval research vessel, and on land at a Brooklyn plant of the Standard Oil Co. of New York. No information is given, in a recent report of the association, as to the nature of the fixateur besides saying that it is a heavy, black, pasty substance of the consistency of axle grease. To the amount of 1 per cent of the finished product the fixateur is melted and blended or is placed on the top screen of four horizontal screens which extend through the entire diameter of a tank, about 20 ft. high and 12 ft. diameter. The oil is entered through the top of the tank and seeps through the fixateur. The lower screens catch that part of it which oozes through the first screen, thereby holding it up where more oil can encompass it. When the oil has thus been fixated it is introduced by pumps into the mill, which is a cylindrical tank about 2 ft. high and 3 ft. in diameter, inside of which are the mixers, consisting of arms with balls at the ends. Other forms of ball or tube mills may be used. After the fixated oil and coal dust have been thoroughly compounded, the new mixture is pumped into storage tanks, ready to be pumped through the usual pre-heaters to the burners.

Colloidal fuels may be given the stable life appropriate to the duty desired. Months after mixing the

RESULTS OF BOILER TESTS OF COLLOIDAL FUEL

	Grade Numbers		Viscosity 1104 sec. Engler Sulphur 4% Mexican Reduced			
	13	14	Test No.1,	Test No.2	Test No.3	Test No.4
1. Grate surface, sq. ft.						
2. Total heating surface, sq. ft.	4840	4840	4840	4840	4840	4840
3. Date	3/24	4/21	3/7/19	3/10/19	3/11/19	3/12/19
4. Duration, hours	8	8	8	8	8	8
5. Kind of liquid colloidal fuel, grade	13	14				
6. Steam pressure by gauge, lbs. per sq. in.	81.8	80.8		82.8	80.60	76.10
7. Temperature of feed water entering boiler, deg.	79.3	111.4		109	106.7	103.6
8. Percentage of moisture in steam or number of degrees of superheating, per cent or deg.	2.8	2.8				
9. Percentage of moisture in liquid colloidal fuel, per cent.						
10. Liquid colloidal fuel per hour, lb.	1286	1076	1159.5	1146.5	1054.7	982.75
11. Liquid fuel per sq. ft. grate surface per hour						
12. Equivalent evap. per hour from and at 212°, lb.	17486	15942	16200	17202	16567	14632
13. Equivalent evap. per hour from and at 212° per sq. ft. heating surface, lb.	3.61	3.29				
14. Rated capacity per hour from and at 212°, lb.	403 B.H.P.	403 B.H.P.	403	403	403	403
15. Percentage of rated capacity developed, per cent.	126%	115%	110.6%	122%	118.8%	105%
16. Equivalent evap. from and at 212° per lb. of dry coal, lb.	13.6	14.72	13.97	14.85	15.51	14.89
17. Equivalent evap. from and at 212° per lb. of combustible, lb.						
18. Calorific value of 1 lb. of fuel by calorimeter, B.T.U.	17200	16670	18482	18482	18482	18482
19. Calorific value of 1 lb. of combustible by calorimeter, B.T.U.						
20. Efficiency of boiler, furnace and grate, per cent.	76.8	85.3	73.3	75.94	79.46	76.8
21. Efficiency based on combustible, per cent.						

Average efficiency, 76.37%

COMPOSITIONS—COLLOIDAL FUELS	Grade 13	Numbers 14
	%	%
Coal		30
Coal (Pocahontas)	30	
Coal Tar, etc.		12
Fixateur	1.5	1.2
Mexican Reduced	28.8	
Texas Navy Oil	8.5	6.8
Pressure Still Oil	31.2	50.0
	100.00	100.00

ANALYSIS GRADE No. 13

Ash	3.20%
Sulphur	1.27%
Viscosity 70° F.	67.5° Engler
Sp. Gravity 70° F.	1.0431
Flash	250° F.
Fire	285° F.
Moisture	.2%

GRADE No. 14

Ash 2% Sulphur .2%

composites showed little or no deposit. Fixateur and fixated oil are readily made and may be shipped anywhere. On burning, the combustion is so complete that with fair coal there is no slag and very little ash left.

Operating Tests with Colloidal Fuel

Different grades of colloidal fuel for naval, power and industrial use were made and burned in a trial unit. The table shows the results of comparative tests of burning colloidal grades Nos. 13 and 14 and "Mexican reduced" oil on the same boiler with the same burners and under similar conditions.

Characteristics and Virtues of Colloidal Fuel

These fuels possess unique characteristics and certain advantages shared by no other fuel oils. Heretofore engineers have thought of liquid fuels always as lighter than and floating upon water. Colloidal fuels are heavier than water unless the coal content is very small. It is as easy to stabilize 30 per cent to 40 per

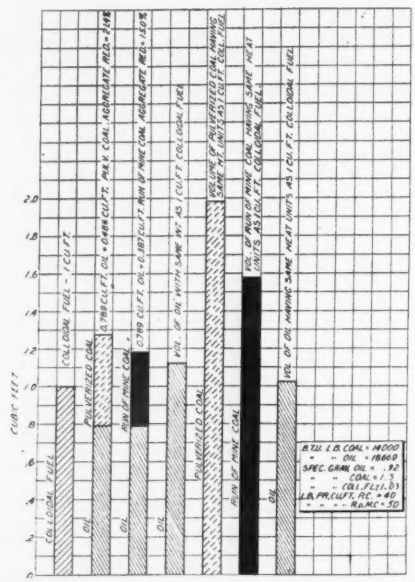

COLLOIDAL FUEL - 1 CU.FT.
PULVERIZED COAL
OIL
RUN OF MINE COAL
VOL. OF OIL WITH SAME WT. AS 1 CU.FT. COLLOIDAL FUEL
VOL. OF PULVERIZED COAL HAVING SAME HEAT UNITS AS 1 CU.FT. COLLOIDAL FUEL
VOL. OF RUN OF MINE COAL HAVING SAME HEAT UNITS AS 1 CU.FT. COLLOIDAL FUEL
VOL. OF OIL HAVING SAME HEAT UNITS AS 1 CU.FT. COLLOIDAL FUEL
CUBIC FEET
B.T.U. LB. COAL = 14000
" " OIL = 18669
SPEC. GRAV. OIL = .92
" " COAL = 1.3
" " COLL. FUEL = 1.03
LB. PER CU.FT. REC. = 40
" " " MEX. = 50

FIG. 1. VOLUMETRIC COMPARISONS BETWEEN OIL, COAL AND COLLOIDAL FUEL

cent of coal as 5 per cent, and it takes no more fixateur and no different treatment to accomplish.

Colloidal fuels are far safer in storage, whether afloat or ashore, because they may be put under a "water seal" of some inches of water or other fire-extinguishing compound which will also arrest evaporation, losses and deterioration. Thus these new liquid fuels not only have a high flash and fire test, but they may be actually "fireproofed" for storage and carriage.

When, during the war, loaded tankers were assailed by gun fire and torpedo fire, when the tanks of oil-burning destroyers or battleships were damaged, they were soon enveloped in hurricanes of fire and ships and survivors struggled in a sea aflame. But with colloidal fuels a blaze in or from one tank would not necessarily involve another. What leaks upon the sea sinks and is thus self-extinguishing. It is especially interesting to note that when poured while blazing upon a water surface 98 per cent of it will sink, or, rather, it all sinks and about 2 per cent rises, occasioning an irridescent film. Among other favorable points are:

1. An increase in efficiency is obtained, in comparison with lump or mine-run coal burned on grates. This is due principally to the lower percentage of excess air required for combustion and to the fact that there is no loss of combustible in the ash.

2. The flexibility of operation is equal to that of oil, and the equipment may be so arranged that the feed is under perfect control and that sudden demands or overloads can be met.

3. Lower grades of coal than those now used can be successfully burned. This is one of the true lines of evolution for combating fuel famine.

4. There will be less moisture in the fuel as fired, giving, in comparison with ordinary steam coal, uniform furnace temperature conditions.

5. In case of emergency the firing of the boilers can be stopped immediately.

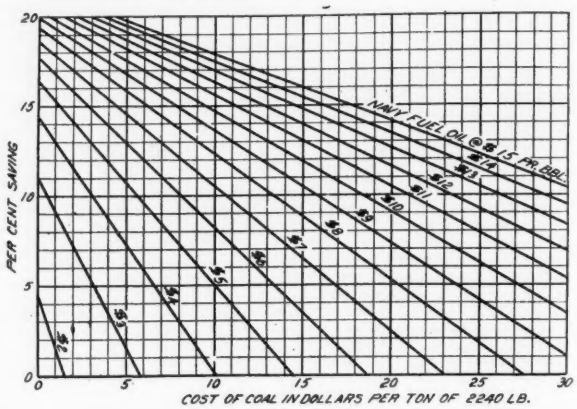


FIG. 2. DIAGRAM SHOWING COST SAVINGS WITH COLLOIDAL FUEL

6. Steam can be made quickly and rapidly.

7. Use on shipboard would greatly simplify the labor situation, already strained. The work of preparing, kindling and maintaining fires, whether the vessel is in port or on voyage, in navy cruising or in battle emergencies, is exacting, exhausting and hard. Reduced labor cost means more mileage, shorter delays and more nearly continuous service.

8. Skilled feed control takes the place of extra arduous labor, so severe that its amelioration is a boon and an uplift to one of the most trying of vocations.

9. Smoke, soot, cinders, sparks, stoking and fire hazards can be virtually eliminated, as can almost all the handling of ashes and the cleaning of fires, ashpans, flues, tubes and smoke boxes.

10. There results more continuous steam pressure, greater sustained boiler capacity, increased boiler efficiency, reduced cylinder back pressure and more highly superheated steam, as compared with mine-run or lump coal firing. More heat units in the coal are utilized—heat units that would otherwise escape through the stacks.

In marine steaming service the use of colloidal fuel will effect a reduction in units of fuel space per mile run. This will mean with the same tank or bunker space a longer "cruising radius" without refueling, or con-

versely, that storage can be smaller, and less actual volume of fuel need be carried. Colloidal fuel requires no different equipment from that used to burn fuel oil. The burners need be no larger and are easily kept clear of deposits; there has been no choking of pipes, and storage has presented no difficulties; the coal has remained in suspense for several months, and if sedimentation then begins, a short stirring renews the life of the composite as regards the suspense of carbon particles or the dissolution of a forming jelly.

The volume occupied by colloidal fuel after manufacture, the volume before colloiding, and the volume of oil with the same weight as a cubic foot of colloidal are shown in Fig. 1. This chart also shows that pulverized coal is nearly twice as bulky as colloidal fuel for the same number of heat units.

Regarding the saving of cost involved in the use of this fuel, the report of the association states that, for example, with coal at $4 per ton and oil at $4 per 50-gal. bbl., the saving is $2 per ton. With coal at $5 per ton and oil at $7 per bbl., the saving is close to $6 per ton. A chart developed by Mr. Bates, Fig. 2, shows the per cent savings in cost of colloidal fuel over regular oil fuel for equal heat values.

Different grades of coal have been experimented with, ranging in ash content up to 25 per cent. An especially good carbon material has proved to be a coke containing, it is stated, 98 per cent carbon, no ash and no sulphur. The mobile paste, which is about half oil and half coal, is said to develop the largest number of heat units per unit volume which may be readily pumped to the combustion chamber. As a liquid the percentage of coal should be under 40 per cent by weight.

The New Pompton Lake Hydroelectric Plant

A NEW hydroelectric plant at Pompton Lake, which is now under construction, provides an interesting example of the utilization of small water powers. When it was found that the present gas-engine-driven plant was inadequate for the needs of the community,

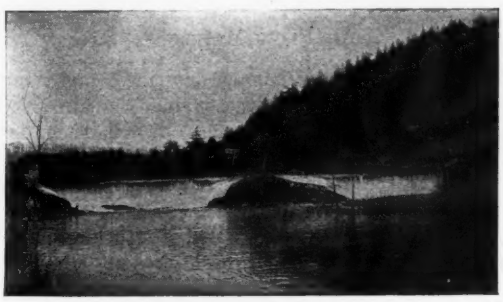


FIG. 1. POMPTON LAKE FALLS

serious consideration was given to the installation of a steam turbo-generator; but in view of the high cost of coal and the desirability of conserving fuel, it was finally decided to put the local waterfall to work. This fall is 22 ft. high and has a considerable volume of water, so that it can take care of the power demands of the neighborhood for some time to come.

The plant will be built along the same general lines as the hydroelectric plant of the Society for Establishing Useful Manufacturers, at Paterson, N. J., which is close to Pompton Lake and has proven thoroughly satisfactory in operation. It will contain two vertical generating units, one of 250 kv.a. and the other 100 kv.a., and current will be generated at 2300 v. to permit transmission over a considerable distance.

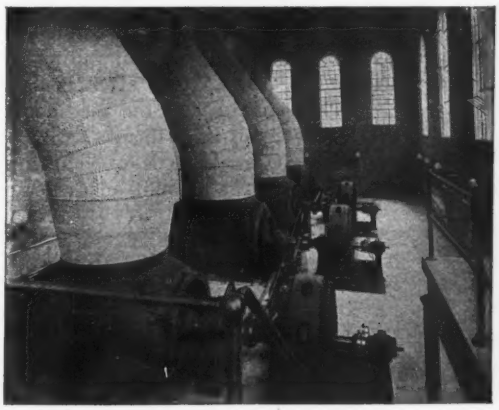


FIG. 2. INTERIOR OF SOCIETY FOR ESTABLISHING USEFUL MANUFACTURERS' PLANT AT PATERSON, N. J.

Power will be supplied for lighting the borough, which has 3000 population, and also be available for industries, which, it is hoped, will be attracted to the locality.

A LARGE number of discharged disabled men of the army, navy and marine corps will need special investigation and study before adequate retraining courses can be recommended, according to the Federal Board for Vocational Education; and in many instances a continued course of orthopaedic and other treatment is necessary to be continued during vocational instruction. Arrangements have been made by the Federal Board for "try-out" courses of some of the larger cities where the vocational work can be given, and where at the same time such expert supervision or treatment as the case may require may be had. Thus far arrangements have been made for the "try-outs" at Boston, New York, Cincinnati, St. Louis, Chicago, and Minneapolis, with other centers under consideration.

The men who are assigned to the "try-out" courses will of course, receive their $65 per month for subsistence, allotments to dependents, and all expenses of special medical or orthopaedic treatment defrayed by the Federal Board. When the special difficulties have been overcome, the man has been gotten into best possible shape, the best course for him decided upon, and he is then started upon that course in some appropriate institution, or perhaps directly in the industry itself, and a place is ready for him upon completion of the course, provided by the placement division of the Federal Board, if it is a wage-earning occupation for which the man has trained.

THE GREAT MAN is poised and satisfied—no matter what happens. The little man is always full of trouble; and this trouble he always lays to the fault of others.

Boiler and Turbine Room Instruments*

Meters and Measuring Devices Desirable to Obtain and Maintain a High Degree of Operating Efficiency

IN THE last two or three years great advance has been made in the development of CO_2 recording machines, and many of the former criticisms have been met, but at the present time these machines are still far from ideal for the fireman's use. Much trouble is experienced in keeping the machine and sample piping in working order, and there is a gradual falling off in the accuracy, beginning immediately after being put in proper repair. The reliability of the readings then depends upon the frequency of adjustment.

The principle of the CO_2 recorder is excellent in that it gives a direct measure of the amount of air required

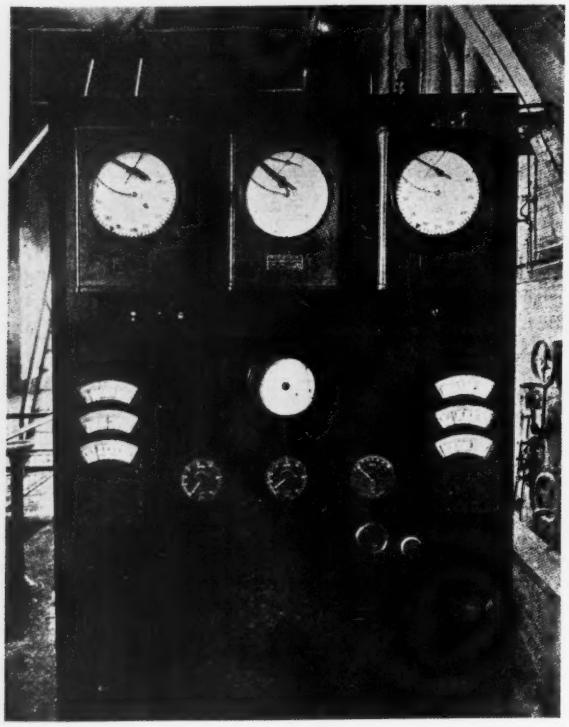


FIG. 1. TYPICAL BOILER CONTROL PANEL

to utilize the utmost heat value of the fuel, and gives, therefore, an indication of the most efficient combustion. But good over-all efficiency does not necessarily follow from good combustion efficiency, since it is affected by the condition of the surfaces of the boiler, and as an indication of this condition, it is necessary to use a flue thermometer in conjunction with the CO_2 recorder. A temperature standard may then be obtained at different ratings by a test upon a clean boiler using proper combustion, and by reference to this in subsequent operation the flue temperature will indicate when the boiler is dirty. A steam flow meter then also becomes a necessary part of the outfit.

The same functions which are performed by the CO_2 recorder in conjunction with the flue gas thermometer and steam flow meter can be performed by other reliable means, as will be explained. While maintaining the maximum efficiency, a definite amount of combustible must be consumed to produce a definite output for the boiler and to consume this combustible will require a definite amount of air. If the relationship between the amount of air and the boiler output is determined once for all when the boiler is clean and operated at maximum efficiency, this relationship will subsequently serve as a standard by which to operate the boiler. The output of the boiler at any particular moment is proportional to the steam output, provided the feed water temperature is maintained constant and the rate of feed to the boiler is maintained proportional to the steam output.

In holding operation to the standard relationship, account must be taken of the condition of the boiler surfaces. If the surfaces are dirty, the gases must be hotter, so that the water may obtain the same transfer of heat through the tubes, and this will require more coal. There is then an increased amount of coal for the same output, and if the relationship of air to steam is held according to the standard, there will be insufficient air for the increased combustion. There is then a falling off in over-all efficiency chargeable to these two sources: the inefficient heat transfer to the boiler, and the inefficient burning of the coal. But the flue thermometer may be used to indicate this condition. The higher temperature of the gases will be evident in the flues, and by comparison with the temperature known as standard for efficient operation at equivalent rating, the condition of the tubes is indicated.

It would seem that this method of operating the boilers depends upon keeping the boilers clean; however the transfer of heat through the boiler is as much a part of the elements operating toward efficiency of the unit as is the proper combustion, and requires attention to that end.

Air Flow Meters

To accomplish the purposes described, many methods have been devised for measuring the air passing through the boiler. In some cases it has been determined by means of pitot tubes, in some cases by orifices in the pass to the air chamber, and in others by using the boiler setting as an orifice.

When the later method is used, the orifice becomes smaller as the gas passages grow dirty, and the differential indication given by the boiler-orifice is too high as a measure for the actual amount of air. The fireman then reduces the draft in order to maintain the standard ratios of air to steam, and this condition augments the condition of insufficient supply of air caused by dirty heating surfaces, which has been previously explained.

The principal cause of the decrease of the size of the orifice is the formation of slag on the lower rows of tubes in the first pass, and in order to overcome the change in orifice where slag forms, it has been found

* Abstract of report of Committee on Prime Movers, read before the N. E. L. A. at its 42nd convention, May 19-22, 1919.

necessary to place the draft pipe for the differential actuation above several rows of tubes in the first pass of the boiler. It is a question whether or not this is advisable; whether it would not be better to leave the draft pipe below the lower rows of tubes and to instruct the fireman to run in his bar and break off the slag when the temperature appears too high for the amount of steam produced, thus bringing the orifice back to the normal condition as well as making his boiler more efficient and of undiminished capacity.

If the draft in the fire box is too great there will be a tendency to blow through the doors when opened, and the maintenance expense of the fire brick and grates will be increased, and if the draft is too low the tendency will be toward a vacuum in the furnace and infiltration will be accentuated. Holding about 1/10-in. water draft in the fire box on forced draft stokers has been found advisable for these reasons. Where this is adhered to, and where the coal burned and the design of the furnaces are such that no slag forms on the tubes, the draft in the last pass can be used as a direct measure of the amount of air passing through the furnace, eliminating the necessity for a differential pressure measurement.

Remote Control

The method utilizing steam flow and air flow meters and flue thermometers offers a most promising solution to the question of boiler operation at the present time. If it is perfected to a great degree, it will develop the principle of the remote control of boilers. We are entering into a period when one man will operate all the boilers from a central point.

By reference to Figs. 1 and 2, it will be seen how several companies are gradually progressing toward this method of operation. All of these companies use one or the other of the methods just described; that is, the CO_2 recorder, steam flow meter and flue gas thermometer, or the steam flow meter, air flow meter and flue gas thermometer, together with indicating or recording draft gages, giving the pressure in the fire box, the draft over the fire and the draft in the last pass of the boiler.

Boiler Over-All Efficiency Measurement

Another instrument universally used is the tachometer, which gives the speed of the stoker. This may be graduated in various ways to give seconds per revolution, coal per hour or inches of air to be maintained in fire box corresponding to the speed. With provisions for measuring the amount of coal fed to the furnace, the amount of steam produced and the efficiency of combustion of the coal, the over-all efficiency is at all times indicated or recorded as the case may be, and the fire is completely and properly under control.

Some attempts have been made to indicate or record on one instrument the various conditions which have been described and which have a co-relation with one another to efficient operation, in order to avoid the use of several charts for interpretation, and considerable success is being experienced along this line.

Steam Flow Meters

The steam flow meter has progressed greatly since the last report of this committee, and its accuracy as now designed can easily be maintained within 2 per cent.

These meters then may be depended upon for a perfect indication in the boiler room, and also may be used in many cases for the sale of steam.

There are two principles used in the measurement of steam by the best known steam flow meters. One is based upon the orifice method and the other upon the pitot tube. Both of these are accurate in results. The pitot tube has one disadvantage over the orifice: If there is a foreign material being carried along in the steam, it is apt to clog the openings and cause the meter to read in error; however, where there is no danger from this element the pitot tube is just as accurate and reliable as the other.

It might be well to point out here to the users of steam flow meters who have had trouble with the clogging of pitot tubes that this form of meter could be easily and inexpensively changed over to the orifice type of meter, and the change would be readily made by any

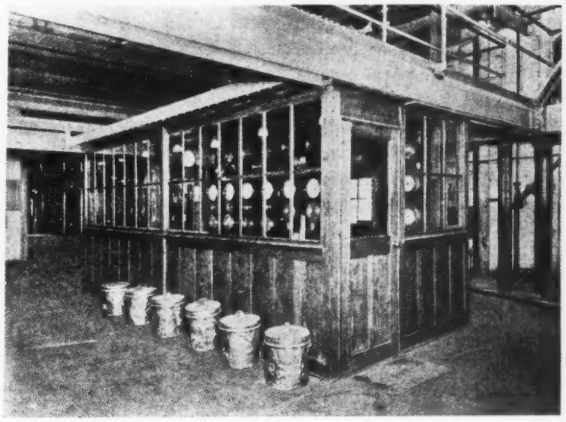


FIG. 2. INSTRUMENT BOARD IN OPERATING ENGINEER'S OFFICE

meter concern. This change, however, should be made by someone who thoroughly understands the characteristics of the flow of steam through an orifice, in order that the connections for measuring the differential pressure can be made in the right way and inaccuracy on this account avoided.

Boiler Plant Efficiency Measurements

Coming now to a discussion of the over-all efficiency of the boiler plant, the instruments used have progressed in proportion with those used for individual boiler operation. Very suitable meters have been designed for measuring the feed water supplied to the boiler. Also meters for measuring the water that is drawn from the boiler in the form of blow-down. Furthermore, recording automatic scales have been developed for recording the weight of coal passing over belt conveyors or through hoppers, so that it is possible to run continuous over-all boiler room tests.

Automatic instruments for measuring coal, however, have not reached the stage of perfection which could be desired, as in order to keep them reasonably accurate they must be continually adjusted. For this reason many plants equipped with the modern boiler of in-

creased size are using the coal larry with the well-known platform scales.

Recording thermometers are coming into more extensive use in various parts of the plant. The installation of economizers calls for the employment of these, and they have proved accurate and essential for efficient operation at this point.

As a matter of fact, regarding all turbine and boiler room instruments, the recording type is becoming popular and shows good results from the point of view of decreased cost of operation of the plant.

Water Meters

The meters used for measuring the feed water may be divided into different classes, one which employs the principle of the V notch weir, another the principle of the orifice and another the principle of the pitot tube, and there are also meters depending upon weighing devices and volumetric meters.

The pitot tube has the same faults in measuring water that it has in measuring steam, and for this reason it is practically eliminated from this class of service.

The orifice type of meter, which includes the Venturi type, is an accurate means for measuring hot water, and is extensively used. The V notch weir, which has greatly advanced in recent years, is pressing the Venturi meter for a place in this field, and its accuracy and practicability have become unquestioned. These types may also be used for measuring the water which is taken from the boiler in the form of blow-down. All three of these types of meters with very little attention can be kept well within the accuracy of 2 per cent.

Indicators for Special Purposes

The station load indicator has a place in every boiler room and turbine room. This is sometimes of the taxi-call type, but many plants have devices of their own design.

Indications for special purposes in various plants are of value. It is noted that thermometers have been used on super-heaters where there is trouble from priming of the boilers, in order to give an indication of this trouble. Water back alarm thermometers are used by some. Damper position indicators find some use.

Turbine Room Instruments

Turbine room instruments have also made considerable advance. We need say nothing in regard to the thermometers, steam gages, speed indicators, etc., which have already become so common, but with the improvement which has taken place in the steam flow meter it has become more and more desirable to equip each unit with a steam flow meter, and by this means an accurate account may be kept of the disposition of the steam produced and a reliable indication given of any trouble which has developed or is developing in a particular piece of apparatus as shown by the increased steam consumption.

Among special devices used in the turbine room, mention should be given to the air bell in connection with condensers as a measure for leakage.

Mention should also be made of the two pen recording thermometer used on jet condensers in certain cases, showing exhaust steam and circulating water discharge temperatures.

The Hudson Cylindrical and Water Tube Boiler

Combination Boiler Gives 80 Per Cent Efficiency During Test. By Mark Meredith

THE commercial success of any power plant depends largely upon the cheap production of steam and on the certainty with which it can be furnished in quantity corresponding to the momentary demand. While manufacturers and engineers have given much care to the improvements in the steam engine, or, rather, to the utilization of the steam, that a reduction may be made in the consumption for a given amount of power, comparatively little attention has been given to securing economy in its generation.

Among the principal features aimed at in boiler construction, or in boiler design, are simplicity of construction, circulation of water, a chamber or means to afford complete combustion, large steam and water capacity to prevent sudden fluctuation in pressure, and large water surface to prevent foaming or priming. Though these and other features are essential, they are never fully contained in any one class of boilers. One design may provide for a large steam capacity, but this it does at the sacrifice of good circulation, or vice versa. In the design of the Hudson patent cylindrical and water-tube boiler erected at Glencraig Colliery Fieshire, the large water-holding capacity and steam reserve of the Lancashire type of boiler, combined with the quick steaming properties and the good positive circulation of the water-tube type, has been aimed at.

This class of boiler is made in two distinct types. For large evaporations the cylindrical element consists of a short two-flued boiler of the Lancashire type, and for smaller requirements it is of single-flued or Cornish type. In either case the cylindrical element is flanked on each side with a series of water tubes, set low in the front and rising at a suitable angle to the back of the boiler. The bottom header of each nest of tubes is connected to a mud drum, at the fore end of the cylindrical element, by a mild steel pipe of large capacity. A T-pipe connects each back header from a point just below entrance of top row of tubes to the back end of the boiler immediately above and between the furnace flues. From a standpipe on top of each header a bent pipe of ample capacity to carry off all the steam generated in each water-tube element connects separately with the steam space of the cylindrical element. The water tubes are expanded into accurately sized holes in tube plates, after which the ends of the tubes are carefully bell-mouthed. No riveting or tube expanding requires to be done on the site, as the boiler is riveted up complete, all tubes expanded into headers, and the whole tested by hydraulic pressure at the works before despatch. Each header is provided with a manhole door, which affords easy access for inspection and cleaning of tubes. At the back end the header ends are in the form of bolted and

jointed covers of strong design, and these can easily be removed in the case of tubes requiring to be renewed. These covers have a man door fitted, as in the case of the lower headers. On the question of accessibility alone, the boiler has much to recommend it.

The water circulation is positive and very complete; it is obtained by feeding the boiler through the front end as usual. This cold water quickly finds its way to the bottom of the cylindrical element, and thence passes to the water-tube elements on either side. The water contained in the tubes is rapidly heated by the hot gases, and at once sets up a natural and vigorous circulation in the direction of the upper end of the tube element. This is in the opposite direction to that in which the hot gases are traveling, and thus greatly assists in the rapid exchange of heat. By the time the water arrives at the upper end of the tube element most of it will have been raised to evaporation point. The equalizing pipe, connecting tube and cylindrical elements allow of easy passage for steam from one to the other.

Reduction of length as found in this class of Lancashire boiler is a point in its favor, as it means that only one-half of the longitudinal expansion can take place. This fact insures only half the ordinary strain on the end plates.

The use of dirty feed water does not cause the trouble usually met with in ordinary water-tube boilers, owing to the fact that the sediment settles along the lower part of the shell and is swept away from there into the mud drum, from which it can easily be blown out. The mud can get into the mud drums, but has difficulty in getting into the tubes.

In this boiler the tubes are so situated that there is no risk of their getting burned out, the gases not meeting the tubes until they have left the furnace and traversed the furnace tubes. In the furnace tubes, while the gases are at their hottest, the quantity of water around the furnace tubes is greater than at any other part of the boiler. The rapid circulation helps to keep any scale in the water from settling on the tubes or shell plates, owing not only to the rapidity with which the water is passed over the surfaces, but also to the fact that all water coming into the tubes must do so by way of the bottom connecting pipes from the bottom of the boilers; the exit therefrom into the tube elements involves abrupt and rapid changes of direction which result in a large proportion of scale being left in the capacious mud drum.

The cylindrical element measures 8 by 16 ft., which gives plenty of room for steam getting away from the water in a very dry condition. The very large quantity of water contained provides a large thermal storage. The thermal storage is as ample as that obtained in a Lancashire type boiler twice its length, owing to the rapidity with which the tube elements on each side will heat up the water they contain.

The Hudson boiler can be worked to the maximum or minimum evaporation with the same high efficiency and economy in fuel, while it will give twice the evaporation of a Lancashire boiler for an equal floor space. It will effect a saving in fuel of from 25 to 35 per cent over the latter type. The test conducted at Glencraif shows that the efficiency of the boiler can most favorably compare with that of any other type.

SIZE OF BOILER

Lancashire element	16 ft. long, 8 ft. dia.
Two water-tube elements	Each with 45 4-in. o/d tubes
Total heating surface	2042 sq. ft.
Duration of test	4 hr.
Weight of feed water per hour	7.650 lb.
Temperature of feed to boiler	118 deg. F.
Gage pressure	76 lb.
Absolute pressure	90 lb.
Fuel used	Smudge
Calorific value of 1 lb. of fuel dried	9.20 B.t.u.
Grate area	44.3 sq. ft.
Weight of fuel fired per hour	1180.5 lb.
Weight of fuel fired per sq. ft. of grate per hr.	27.1 lb.
Water evaporated per lb. of fuel fired	6.5 lb.
Equivalent evaporation from and at 212 deg. F. per in. of fuel as fired	7.35 lb.
Equivalent evaporation from and at 212 deg. F. per lb. of dried fuel	8.46 lb.
Equivalent evaporation per lb. of carbon value of fuel from and at 212 deg. F	13.3 lb.
Percentage of CO_2 in escaping gases	10.12
Temperature of escaping gases	552 deg. F.
Draft in inches of water	0.61
Weight of ash and clinker per hour	288 lb.
Percentage of ash and clinker in total weight of fuel used	24
Efficiency of boiler	80 per cent

The Service Song of Coal

BY BENJAMIN OGDEN WILKINS

AGES ago I was tall, virgin timber,
Standing magnificent, reaching the sky,
Waving my heavy arms, gracefully limber,
Over creation—while decades swept by.

Then came the man, who for centuries over me
Worked at his plowing, and hunted his meat;
Heedlessly going his way, unsuspectingly
Blind to the treasure there under his feet.

After came those who were curious, guessing
Deep in the ground I was buried in mold,
Striking their borings in search of the blessing,
Seeking black earth far more useful than gold.

Searching, they found me, mysteriously hidden
Away from the sunlight, and blackened with death;
Gravely and solemnly raised me, unbidden,
Taught me to burn with a fiery breath.

Carried me gladly to the ports on the ocean,
Took me to markets where the great rivers ran—
So I was able to work with devotion,
Helping to lighten the burden of man.

Under the sea and on high in the heaven
Engines have life with my blood in their veins;
Man has delivered the clod of its leaven—
Freeing a world from the weight of its claims.

—The Nation's Business.

W. S. ELLIOTT

HE LIKES TO TACKLE PROBLEMS, AND SOLVE THEM HIS OWN WAY. DEVOTED HIS EARLY EFFORTS TO ELECTRIC RAILWAYS, BUT SWITCHED WITH GREAT SUCCESS TO POWER PLANT ACTIVITIES. BY ARTHUR L. RICE

EVERY man who gets anywhere has first to get born some time. From his later achievements, Mr. Elliott seems to have chosen well his time, place and parentage for this important event. Real Scotch blood, which has been the fortunate inheritance of so many of our successful men, was his from both his parents, John Elliott and Catherine Adams Elliott.

Also for his first night performance he chose, as have so many who have achieved the pinnacle of leading man in their own companies, a farmhouse for his stage setting. It is likely that when he began the business of life on Oct. 8, 1863, near Wellsville, Columbiana Co., Ohio, he set up the policy he has since followed of "starting with a clean slate," refusing to follow the other fellows' mistakes, demanding maximum of efficiency of production and insisting on good working conditions.

W. S. Elliott

Not appreciating that they were nurturing a future prominent engineer, as Master Elliott did not at that time disclose the goal toward which he was progressing, his parents "brought him up" with the rest of the young stock on the farm, among which were included two sisters and a brother, in the normal, healthful way of the average farm boy, with the usual complement of "chores," stone bruises on heels, weeding of the garden and occasional rainy-day fishing trips.

But his boyhood was not carefree, for when he was 6 yr. of age his father died, and the responsibility of the farm fell to the mother and children, who carried it on until he was 13 yr. old, when the family moved to Wellsville.

From the public schools of the town he gained his early education, which Mother Catherine, with Scotch wisdom, insisted must be had. But at 17 yr. W. S. maintained the opinion against all comers that here was where he started his career. And he did. For a dry-goods and grocery store at the magnificent salary of $1.50 a week. Mr. Elliott has always, as aforesaid, insisted on having the fun of making his own mistakes. This was apparently one of them, for the enormous salary that he drew proved too much for the firm, and despite his efforts to save the wreck, which continued up to the very last, the concern went bankrupt. Another thing that Mr. Elliott is particular about is claiming the blame for his mistakes; and he openly attributes this failure to the heavy drain that the salary paid him put upon the firm's resources.

For fear, therefore, that another venture might bring a like disaster, he returned to school and prepared for Sibley College, Cornell University, which he entered in 1883, graduating in 1887 with the degree of Mechanical Engineer in Electrical Engineering, thus proving his Scotch thrift by acquiring two titles in a single degree. Probably the college annals might reveal many happenings of interest during those 4 yr., but we have forborne to search the records, since Mr. Elliott has omitted to claim credit for any mistakes, and the work of later years proves that, at any rate, a solid foundation was laid for sound engineering practice.

One incident only has he mentioned. About the time of his completion of the course, development of the electric railway had begun, and Vandepoele built a 2-mi. road at Scranton, Pa. The electric railway and electric motor were novelties; the under-running trolley was unknown, and the trolley wheel ran on top of the wire with a cable to the controlling apparatus to carry current, and incidentally to drag the trolley along the wire. This road was, of course, single track, with turnouts for passing cars, and the fellow who got on the switch first took a pole, lifted his trolley off the single wire and waited for the other fellow to go by. The possibilities of fireworks and language when running on a cold, rainy day can be imagined better than

described in a paper that has to pass through the U. S. mail. But young Elliott joined two of his classmates in making, as far as known, the first efficiency test ever made on an electric street railway, and the data served him as the basis for a graduation thesis.

Also the experience opened for him an avenue for employment with the Sprague Electric Railway & Motor Co., and while with them he designed what is believed to be the first electric hoist taking current from a central station, which was used in building the Kansas State Capitol. For 8 yr. he continued in electric railroading, going with the Edison Co., when it absorbed the Sprague Co., in the railway department of the Chicago office, and taking a full share in the development of the street railways in the Middle West.

But in 1895 combinations of the then existing electrical companies seemed likely to lessen the opportunity for advancement, so Mr. Elliott, changing to what he believed to be the larger mechanical field (here he was proving the Scotch canniness of that double-barrelled degree), joined the sales department of the Stirling Co. of Chicago and took charge of the Pittsburgh district.

Water-tube boilers had become popular where good water was available, but where scale filled the tubes, the difficulty of cleaning them had proved a drawback. Here was a problem to be solved. Mr. Elliott liked problems. Naturally he claimed this one as his, with the result that his design of a boiler tube cleaner successfully removed the objections before raised, and the water-tube boiler rapidly increased in popularity, continuing its gradual replacement of other types up to the present time.

In 5 yr. Mr. Elliott rose to the position of sales manager of the Stirling Co., increasing the use of the Stirling boiler greatly by his methods of marketing until 1904, when he resigned from the Stirling Co. and practically retired from business. That is, he thought he did. That think was another mistake, although it isn't one that he claims.

Several years before he had organized the Liberty Mfg. Co. to make and market boiler tube cleaners. And from time to time, having nothing else to do, he gave some personal attention to this business. That was where he did make a mistake, if he wanted to stay retired, for the business grew rapidly. It brought him into contact with the steam accessory field and he found another problem. That was too much; he never could let a problem alone.

A full line of power plant accessories, developed on good engineering lines to meet the needs with which he frequently came in contact, that was the problem, and he set his efforts and ability in that direction, organizing the Elliott Co. to make and market these accessories.

Here again he "started with a clean slate," as he says, and "built the business out of a clear sky." He didn't propose to follow anybody's mistakes. He was going to have the fun of making his own on his own responsibility. If he made a mistake, and some apparatus didn't work right—and he admits he did—he wanted to have the fun of finding it out and remedying the fault. Those mistakes were his private property; all the "bugs" in the apparatus were pets to be added to his personal collection, and nobody could buy any of them. Who but a Scotchman would think of making a private collection of mistakes and "bugs"?

Numerous patents have, of course, resulted; some of them fundamental, which have stood against all litigation, indicate Mr. Elliott's ventures away from the beaten path and his wanderings in ways unknown before, but which are now everyday thoroughfares of practice.

That his vision of the problem and his solution were correct is proved by the growth of the company that bears his name from a small beginning to a main plant at Jeannette, Pa., that covers 4 acres of ground, and a branch plant at Springfield, Ohio, covering 2.5 acres.

Mr. Elliott claims that he hasn't any hobbies. Presumably he means that he doesn't play polo, collect old masters or support a racing stable. But he has that collection of "bugs," and he insists that to make good machinery requires a good plant, good working conditions and the best tools the market affords. And he has made this hobby pay.

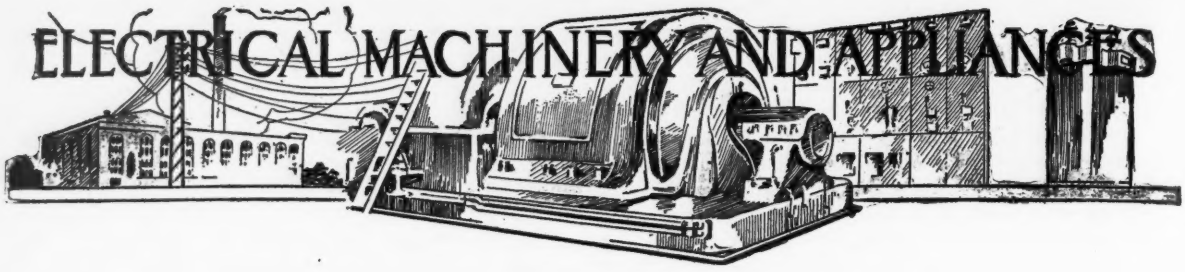
Another hobby is work. Mr. Elliott believes that the best recreation is changing one's line of thought; turning from one task to another, and tackling a different problem. "Work as long as you're awake," is his slogan for success, and he has proved its value.

While Mr. Elliott is approachable and easy to meet, let nobody fall into the error of thinking him lacking in firmness. He has firm convictions, knows why he believes as he does, and has no hesitation in stating his convictions and his reasons for them on occasion in terms that leave no room for doubt.

He has, however, one hobby outside his business; in fact, a string of them, and, like his business hobbies, they bear the name of Elliott. The first one he acquired when in 1890 he persuaded a charming young woman, Miss Anna M. Leyden, to join the Elliott organization and become Mrs. Elliott. The rest, like his other hobbies, are strictly his own design, and consist of three sons and a daughter, all of whom agree that they are as proud of him as he is of them. And this is saying a lot. For the eldest son, a graduate of Cornell University and of Pennsylvania State College, carried a lieutenant's commission during the war, and Daughter Margaret is at the charming age of girlhood that prepares for college. The other boys—well, they're still in high school, and "dad" isn't quite sure yet whether he'll redesign them or not. Anyway, if there are any "bugs" in them he'll find it out before he turns the boys loose, and he'll remove those "bugs" to add to his collection. And mother, the lieutenant, daughter and the boys agree that "father is all right," which, after all, is about as much success in life as any man has reason to ask for.

In Sweden the power used increased from 1910 to 1915 as follows: Steam engines from 332,000 hp. to 422,000 hp.; oil and gas engines from 33,000 hp. to 55,000 hp.; water powers from 546,000 hp. to 850,000 hp. The total increase was from 911,000 hp. in 1910 to 1,322,000 hp. in 1915.

President of National Coal Association declares that there is a shortage in United States of 90,000 miners, and that country faces 50,000,000-ton shortage of bituminous coal.



A Study of Dynamo Electric Machinery---IV

THE SERIES GENERATOR, ITS THEORY OF OPERATION, CHARACTERISTICS AND APPLICATION. BY OTTOMAR H. HENSCHEL

WITH REFERENCE to the schemes of connections employed, there are practically but three types of direct-current dynamos, namely, the series wound, the shunt wound and the compound wound machine. The simplest of these is the series generator and while formerly employed quite extensively in connection with the early Brush and T. H. arc lighting systems, this machine is today practically out of use except, perhaps, for special classes of service, as in the Thury system of high-voltage transmission employed to some extent upon the European continent. Shown in Fig. 16 is an elementary diagram of connection of this type of generator.

Ordinarily, the field coil winding consists of a comparatively few number of turns of heavy wire connected as shown, and as the name of the machine implies, in series with the armature. Due to the ability of the field structure to retain a slight degree of magnetism—termed residual magnetism—an electro-motive force will be induced within the windings of the armature immediately upon this member being set in rotation, and the higher the speed attained, the greater will be the electromotive force developed. With the external circuit open, however, no current will flow, and as a consequence that electromotive force which is induced in the windings of the armature is limited by the speed of rotation.

Upon connecting a load across the terminals of the machine, the circuit is closed, and as a result a flow of current occurs, which in passing through the field coil provides the necessary magneto-motive force by means of which an increase of magnetic flux is established. The armature conductors will therefore (assuming the speed to remain unchanged) be cutting a greater number of lines of force, thus producing a corresponding rise in voltage. It is obvious, then, that if more load be added to the terminals of the machine in such a manner as to reduce the value of the external resistance, increased field magnetism accompanied by voltage will result.

Where series machines have been employed, this scheme of load connection has generally not been used. Instead of connecting the load in such a manner as to cause a decrease of external resistance, the various elements comprising the load were, as exemplified in the series arc lighting system, connected in series not only with the machine, but also with one another. With this scheme, an increase of load is followed by an increase of external resistance and a tendency on the part of the voltage to drop. This action may, however, be counteracted by the use of proper regulating devices, which cause a building up of the line voltage with an increase of load, the increase in voltage being dependent upon the resistance added to the circuit.

A simple means of regulating the voltage of a series generator is that shown in Fig. 17. By the employment of an adjustable shunt connected across the field winding, any desired portion of the total current flow may be caused to pass through the shunt, thereby limiting the amount of current passing through the field winding to that required for the excitation necessary to provide the required terminal voltage.

Series-wound generators are frequently called "constant-current" machines, not because they are inherently such, but because of the readiness with which they may be made to deliver constant current by the application of the proper regulating devices.

RECTIFICATION OF CURRENT

THE ELECTROMOTIVE FORCE induced in a coil or set of coils revolving between the poles of a magnet is, as was explained in Part II of this series, alternating in nature; that is, it alternates through positive and negative values; in other words, it is an alternating electromotive force and the current which is sent through a circuit by such an electromotive force is obviously an alternating current. Where, however, the machine is to deliver so-called direct or unidirectional current, means must be provided for its rectification. This is accomplished by means of a commutator consisting essentially of two or more copper bars connected to the windings in a manner to be explained later and supported parallel to the shaft by some form of framework, which not only insulates the bars, one from the other, but also from the shaft upon which the whole is mounted.

Where but a single coil revolving between the pole faces of a bi-polar machine is employed, the arrangement would be as indicated in Fig. 18. Coil C, mounted on shaft S, has its terminals connected to metallic segments of the commutator (also carried by the shaft), with the center lines of the slots between the two segments perpendicular to the plane of the coil. Bearing against these segments are the brushes, to which in turn are connected the leads joining with the external circuit.

As the coil is made to revolve, an electromotive force is induced therein, this electromotive force reaching a maximum value when the plane of the coil is parallel to the lines of force and at a minimum value when the plane of the coil is perpendicular to the lines of force. As the coil moves to cut the maximum number of lines of force the brushes are as at A, in contact with the segments, and as a consequence the electromotive force (and current) will vary in the external circuit just as it varies within the coil. With continued rotation, the coil will reach such a position as will bring its plane perpendicular to the lines of force, as at B, at which point the direction of electromotive force induced within the coil is changed, while, due to the fact that at this point of the cycle each of the segments is brought into contact with the other brush, the direction of electromotive force (and current) in the external circuit remains unchanged. As a consequence the electromotive force curve will be as shown at C, and as the number of coils (and commutator bars) increases the electromotive force curve will tend to assume the form of a straight line, such as at D.

By the employment of two coils placed at right angles with one another, and each provided with its own set of segments, the electromotive force curves are as shown at C, Fig. 18, but with the two curves displaced by 90 deg. If, however, these coils instead of being connected "open" as the form of connection in Figs. 18 and 19-A is termed, be connected as at B, Fig. 19, the resultant electromotive will be equal to the sum of that induced in each of the coils.

Armature Reaction and Field Distortion

Two distinct actions, the combined effect of which is termed armature reaction, occur in every dynamo electric machine; one of these is termed the demagnetizing action, while the other is referred to as the cross

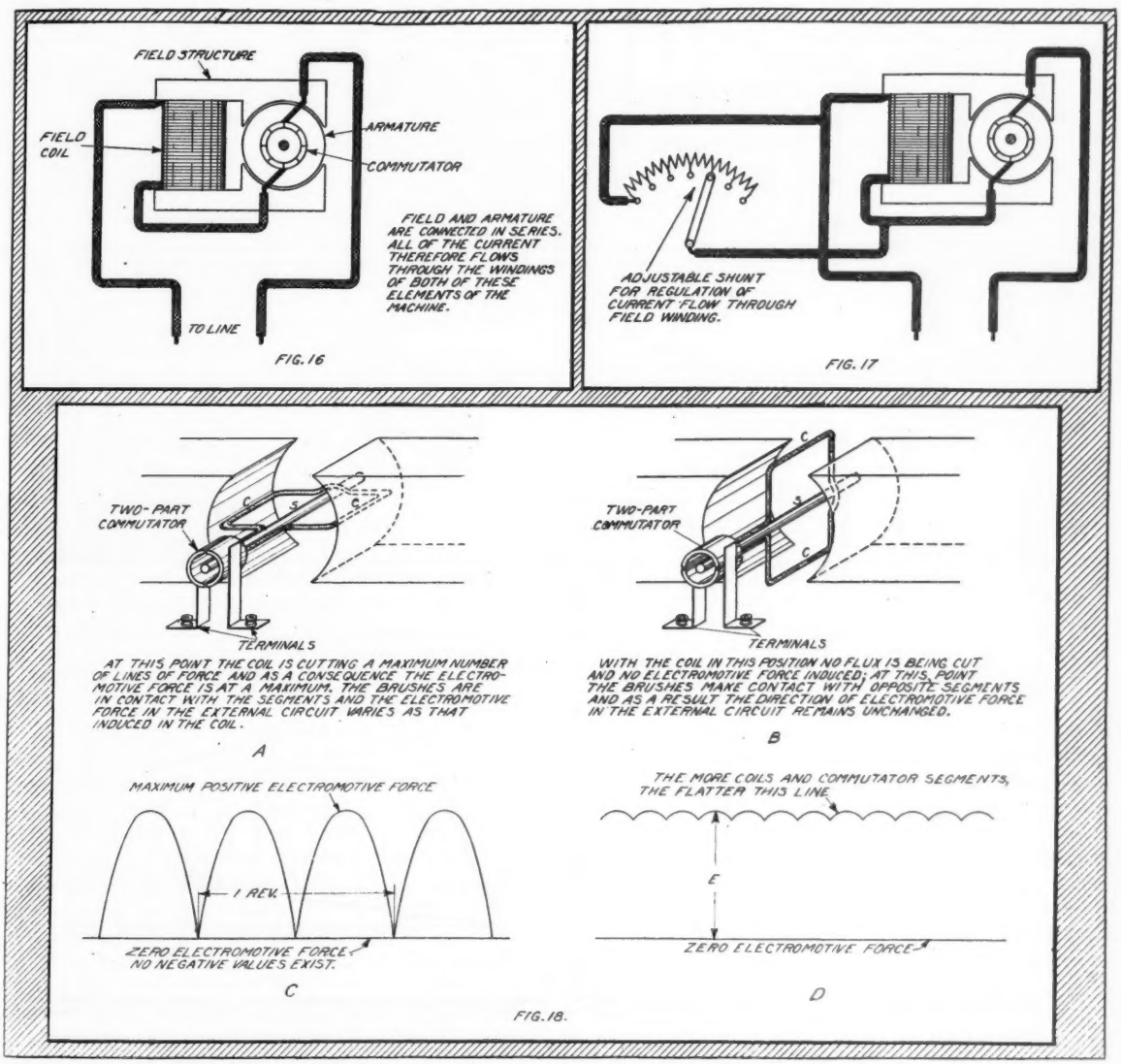

FIELD STRUCTURE
FIELD COIL
ARMATURE
COMMUTATOR
FIELD AND ARMATURE ARE CONNECTED IN SERIES. ALL OF THE CURRENT THEREFORE FLOWS THROUGH THE WINDINGS OF BOTH OF THESE ELEMENTS OF THE MACHINE.
TO LINE
FIG. 16
ADJUSTABLE SHUNT FOR REGULATION OF CURRENT FLOW THROUGH FIELD WINDING.
FIG. 17
TWO-PART COMMUTATOR
TERMINALS
AT THIS POINT THE COIL IS CUTTING A MAXIMUM NUMBER OF LINES OF FORCE AND AS A CONSEQUENCE THE ELECTROMOTIVE FORCE IS AT A MAXIMUM. THE BRUSHES ARE IN CONTACT WITH THE SEGMENTS AND THE ELECTROMOTIVE FORCE IN THE EXTERNAL CIRCUIT VARIES AS THAT INDUCED IN THE COIL.
A
WITH THE COIL IN THIS POSITION NO FLUX IS BEING CUT AND NO ELECTROMOTIVE FORCE INDUCED; AT THIS POINT THE BRUSHES MAKE CONTACT WITH OPPOSITE SEGMENTS AND AS A RESULT THE DIRECTION OF ELECTROMOTIVE FORCE IN THE EXTERNAL CIRCUIT REMAINS UNCHANGED.
B
MAXIMUM POSITIVE ELECTROMOTIVE FORCE
1 REV.
ZERO ELECTROMOTIVE FORCE. NO NEGATIVE VALUES EXIST.
C
THE MORE COILS AND COMMUTATOR SEGMENTS, THE FLATTER THIS LINE
E
ZERO ELECTROMOTIVE FORCE
D
FIG. 18.

FIG. 16. DIAGRAM OF CONNECTIONS OF THE SERIES GENERATOR

FIG. 17. DIAGRAM OF CONNECTIONS SHOWING METHOD OF ADJUSTING FIELD STRENGTH BY USE OF SHUNTS

FIG. 18. RECTIFICATION OF CURRENT BY MEANS OF COMMUTATOR AND RESULTS PRODUCED

magnetizing action, or, in other words, demagnetization and cross magnetization, respectively.

In Fig. 20 is shown, placed between the two poles N and S, a so-called ring armature consisting essentially of an iron ring upon which are wound eight coils, A, B, C, etc., and connected to eight commutator bars in the manner indicated. Due to their position in relation to the poles of the magnet, coils C and G are cutting a maximum number of lines of force, and as a consequence have induced in them a maximum electromotive force. In the case of coils B, D. F and H the electromotive force induced is considerably less than that induced in coils C and G, while in coils A and E practically no electromotive exists.

As may be observed by the arrows, the direction of the electromotive force induced in each of the coils on each side of the armature is the same, while that induced in the coils on one side of the armature is oppo-

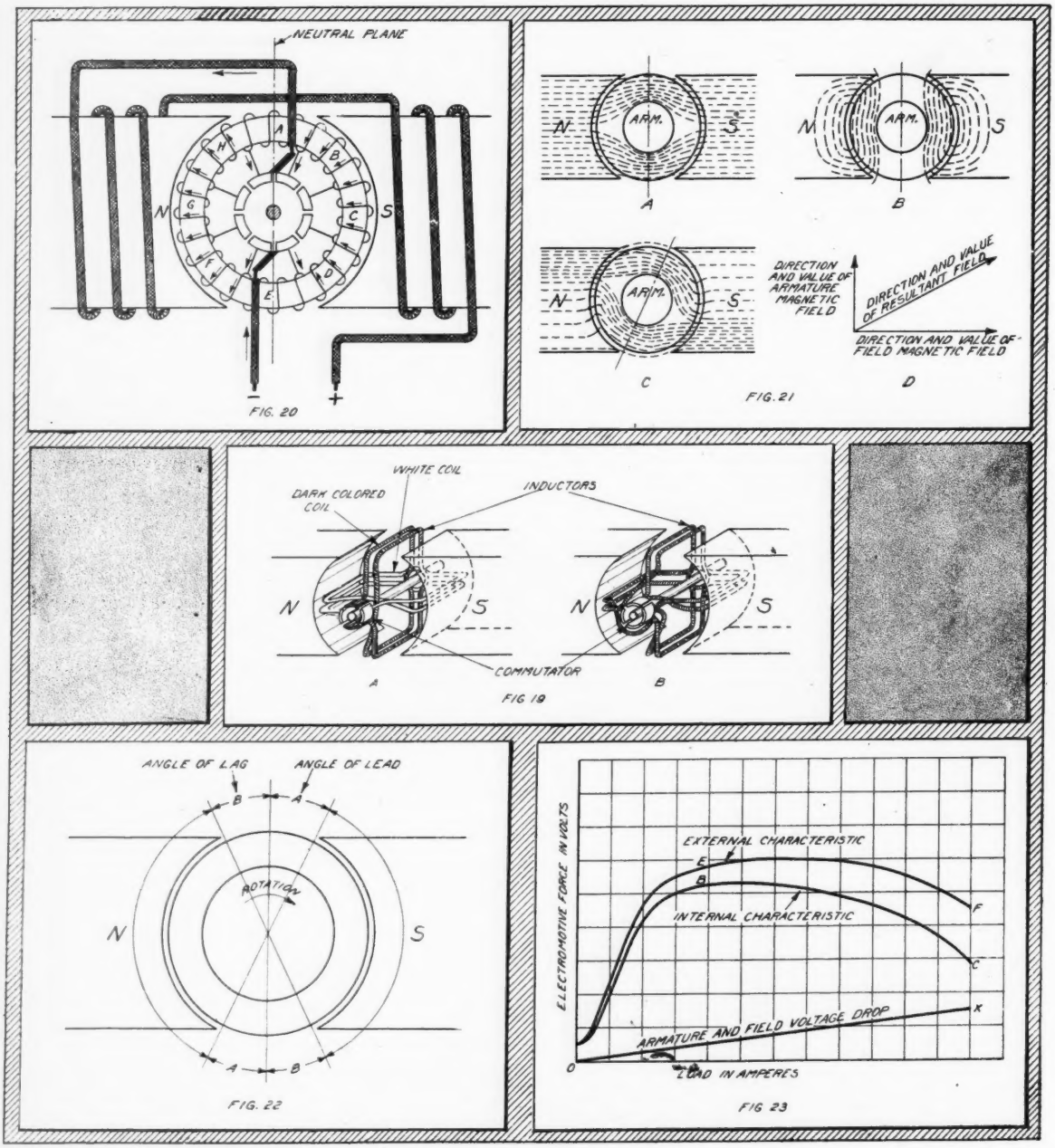


FIG. 19. OPEN AND CLOSED COIL ARMATURE WINDINGS AND ELECTROMOTIVE FORCES PRODUCED
FIG. 20. TYPICAL SERIES GENERATOR WITH RING-WOUND ARMATURE
FIG. 21. ILLUSTRATING FIELD DISTORTION CAUSED BY COMBINED FIELD AND ARMATURE MAGNETIZATION
FIG. 22. IN THE GENERATOR WE HAVE THE ANGLE OF LEAD; IN THE MOTOR THE ANGLE OF LAG
FIG. 23. CHARACTERISTICS OF THE SERIES GENERATOR

site to that induced in those on the opposite side. With the brushes, therefore, placed as shown, the current leaves the armature at the upper brush, and after traversing through the external circuit and the field coil returns by way of the lower brush, half passing through the right-hand side of the winding and the other half through the left-hand side.

It will be observed that each brush for the position shown bears upon two commutator bars, so that the upper brush takes current directly from coils B and H, while the lower brush conducts it to coils D and F. Each brush is of sufficient width to bridge the insulation between any two commutator bars, and by locating the brushes in the plane (termed the neutral plane) indicated in Fig. 20, the coil in which a minimum electromotive force is being induced is momentarily short-circuited, after which, due to the change in direction of motion of the coil, relative to the direction of the magnetic flux, the direction of the induced electromotive force also is changed. This may be readily understood by noting the direction of rotation of the armature and the direction of the induced electromotive force in coil B and the direction of that in coil H.

Although the electromotive forces in coils A and E are comparatively low in value, the current flow, due to the short-circuiting of the coils, may become excessive, resulting in destructive sparking. To avoid this it is customary to employ high-resistance brushes; the short-circuit current and consequently the resulting sparking are thereby reduced to a minimum.

Assume sketch (A) Fig. 21 to represent an armature (Arm.) between poles N and S of a bipolar dynamo, and that no current is flowing through the windings of the armature while the fields are fully excited. As a result, the established magnetic flux will pass from pole N through the structure of the armature in the manner indicated, and thence on to pole S. If, however, the field poles remain unmagnetized, while a current of electricity from some external source is caused to pass through the windings of the armature, a magnetic field of the character shown at B will be set up.

When a generator, the field of which is properly (and externally) excited is brought up to speed, but remains unloaded, no current passes through the armature and the form of the magnetic field will be as illustrated at A. The armature coils in which minimum electromotive force is then induced are as shown in Fig. 20, those lying in a vertical plane midway between the two pole pieces, and as a consequence, in order to realize sparkless commutation, the brushes will be placed as indicated. If, however, the external circuit is closed (that is, the machine loaded) a current will pass through the armature windings, which will tend to create a magnetic field as at B, Fig. 21, but on account of the existing magnetic field, due to the field excitation, a resultant field of the character shown at C will be created, thus causing a crowding of the magnetic lines of force at the tips of the poles under which the conductors leave and a weakening of the field at the tips which the conductors approach. It is, therefore, apparent that the minimum number of lines of force cut will not, as in Fig. 20, be along an axis perpendicular to the center line of the pole pieces, but slightly advanced in the direction of rotation. This necessitates a shifting of the brushes, the degree of advance from their mid position being called the angle of lead.

In the case of a motor, however, the distortion of the magnetic field is such as to require a backward shifting of the brushes; that is, instead of shifting the brushes forward through an angle A, as in Figs. 21 and 22, they must be shifted backward through angle B, ordinarily called the angle of lag.

The conductors included within angles A and B are referred to as the back ampere turns and their magnetizing effect, which is opposed to and tends to weaken that created by the fields, is termed the demagnetizing action of the armature. The remaining turns of armature winding—that is, those not included within angles A and B—tend to create a field at right angles to the main field, and their effect is termed the cross magnetizing action of the armature.

Characteristics

Due to the presence of residual magnetism, a slight electromotive force is induced within the armature windings of a series generator as shown in Fig. 23. By adding load, however—that is, by reducing the resistance of the external circuit—a flow of current is established which in passing through the field windings produces increased flux, and that in turn (assuming constant armature speed of rotation) increases electromotive force. This building up of the voltage continues until the internal voltage drop in the armature becomes excessive, when added current flow results in a dropping off of the voltage in the manner indicated by B C.

The curve representing the armature and field voltage, or R I drop, is, as shown, a straight line, and if the various values of O X be added to the corresponding values of A, B, C, curve A, E, F is obtained. This is known as the internal characteristic of the machine and indicates the manner in which the electromotive force induced within the armature windings varies with the increase of load.

Electrolytic Protection of Metals Against Corrosion

By J. H. Blakey

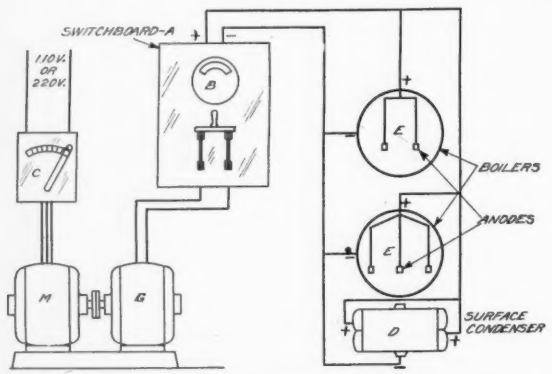
VARIOUS remedies have been proposed for the prevention of corrosion and fouling of those metals which enter into the construction of boilers, condensers, economizers, feed-water heaters, etc., and the Cumberland method of electrolytic protection has already been mentioned in these columns. Since then the system has been perfected and standardized, and has been applied very widely in the ships of the British navy and merchant marine during the war. It is evident that any remedy for the situation which causes the laying up of a ship for from 30 to 60 days in the year will appeal strongly to ship owners.

Since the year 1907 the principle of the electrolytic protection of metals has been recommended by Mr. Cumberland, whose ideas on this subject were first suggested by observing the destructive effect of salt water on the rudders and propellers of ships. The method employed is to use a source of electrical energy sufficient

nected with these areas and the positive to an auxiliary conducting mass taking the part of a soluble anode, which undergoes the corrosion and destruction which would otherwise take place in the metal of the boiler or other vessel.

The idea from which this method of prevention arises is no other than the principle by which corrosion is commonly explained, in attributing to it an electrolytic origin and nature. According to this theory, electrolysis manifests itself whenever two or more different metals, being more or less electro-positive or negative in relation one to the other, are immersed in the same liquid, on the condition that the liquid is alkaline or acid, even to the smallest degree. There are formed between these metals electrolytic couples, of which the action, analogous to that of the elements forming a voltaic pile, tends always to destroy the electro-positive element in each couple.

The employment of an auxiliary mass of metal which is to undergo corrosion and destruction requires the application of a current of suitable strength passing



ELECTRICAL CONNECTIONS FOR CUMBERLAND METHOD OF ELECTROLYTIC PROTECTION OF BOILERS AND CONDENSERS FROM CORROSION

from this mass to those to be protected. In the case of two boilers and a surface condenser, the accompanying drawing shows the electrical arrangement. The current may be furnished by a battery of accumulators, since it requires only a few volts to overcome the electrolytic effects described. However, it is often more practical to make use of a low voltage generator, and if there is access to a 110 or 220-v. system, there should be installed, as shown in the drawing, a convertor group composed of a motor M, branched upon the system and directly coupled to the dynamo G, which will furnish the necessary voltage. For the regulation of the current a switchboard A is employed, together with a variable resistance C and an amperemeter B. Experience has shown that the tension required is from 8 to 10 v., and the density of the current about 0.002 amp., in the case of a condenser, and about twice that amount for the boilers, per hundred square feet of area to be protected. These values may be exceeded without danger, but this involves waste of energy and necessitates the renewal of the anodes sooner than is necessary. The anodes may be of wrought or cast iron. The air in the water causes the formation of rust on the anodes, and the negative is covered with a protecting coat of hydrogen, which not only protects the metal against corrosion, but also prevents fouling. The electrolytic action also favors the precipitation of tartar in the liquid, which simplifies the problem of purification in the case of feed-water heaters.

Making Coils for Small Windings

By Maurice S. Clement

THE following is an easy way to make coils, especially for the amateur who has no coil-winding machine in his workshop. First, take a flat piece of wood about ¾ in. thick, and plot out shape of coil, with right-angle screw-hooks at all angle points, screw-hooks to point away from the center of the form. Run a screw through center, and secure projecting point in a breast drill. Place breast drill in a vise in a horizontal position, with coil form toward the left, taking care to place it so as to allow free movement of the handle. Take a turn with the wire on a nail on the back of the coil form, lead the wire over the edge to the face of the form and turn the handle. This will cause the form to revolve at any desired rate of speed and permit the wire to run over all screw-hooks. Keep sufficient tension on the wire to permit the various turns to lie snugly one alongside the other.

This is considered one of the best ways to wind small coils, for the reason that unnecessary crossing of wires can be prevented. When the specified number of turns have been wound, twist a short piece of wire around each end of coil to hold it in proper shape. To finish the operation, turn all screw-hooks toward the center of the form and slip coil off.

Effect of Improper Coil Spacing

By Henry C. H. Mehciz

AFTER having been rewound, a number of G. E. 57-33 railway armatures were placed in their frames for trial, and instead of operating properly, a number failed to revolve, while those which did move operated for only about a half-hour, when they developed grounds, short circuits or burned out entirely.

A bar-to-bar test failed to show any defects in the machines that would not run, and all practical shop tests showed no defects. The armatures were finally stripped and conditions noted. It was found that the spacing of the coils was 1 to 8 instead of 1 to 9, which they should have been. This caused the coils under commutation to be in the wrong position under the pole pieces when the current was applied, therefore locking the armature in the frame instead of revolving.

The armatures in question are about 16 in. in diameter and have 33 slots, each ¾ in. wide, with the teeth also ¾ in. wide, so that when the coil span was decreased to 1 to 8 the coil would approximately be 1½ in. out of its proper position under the pole piece.

With the armatures that were burned out or developed trouble after being in operation but a short while, it was found that the coils were made without tension on the wire, making the turns uneven and the coil un-

firm. Also the coils were not impregnated and baked but simply given a layer of linen tape and a thin coating of black air-drying varnish.

The coils are made of 3 turns No. 9 double cotton-covered wire, two in parallel and 3 of them laid side by side to form one complete coil. In making new coils for these machines the proper tension was employed on the wire; they were impregnated and baked three times, then properly taped and again impregnated and baked three times before winding. After winding, the whole armature was again impregnated and baked before shipping. Sterling baking varnish was used; and the machines are operating today without the least sign of trouble.

He Can Who Thinks He Can

SOME WORDS OF ENCOURAGEMENT TO THOSE WHO ARE MAIMED. BY H. A. CRANFORD

WHEN just a little fellow, I heard a learned man lecture on the above subject, and although it was many years ago, the impression that was made on me at the time has remained, and many of the thoughts that he expressed have been of great value to me.

I remember going to my home and thinking things over, and deciding that as I wanted nothing in the world so badly as I wanted to be a good machinist, if this man's idea was right I must get busy and go after it.

My father was dead. We were very poor, and there were plenty of places where my scant earnings were needed, and no chance to buy tools, books, etc. There was no machine shop or other industrial works in the village where I lived, in which I could serve an apprenticeship, so the proposition looked pretty blue for me.

Finally a neighbor lady, knowing my love for mechanics, made me a present of a box of tools, such as we give our boys now for Christmas. As I look back, I can see how really worthless they were; to me then, they were the finest ever. An uncle gave me some lumber, out of which I constructed a "shop" in our back yard, and when not running errands or selling papers, you would find me open for business.

By constructing small wheelbarrows, sleds, doll furniture, etc., for the boys and girls, I soon saved enough to buy some secondhand pulleys, screws, etc., out of which I built a lathe. I made rolling pins, potato mashers, etc. These sold well and I had money to buy more tools.

Meanwhile a former friend of my father had moved to our village and opened a paint and paperhanging shop. He offered me work at 50c per day of 12 hr., which was considered fine pay for a 13-year-old boy. I worked for him for 18 mo., working evenings in my shop.

At last came the great chance. A man who owned a small contract machine shop and foundry in the county seat of our county told my mother that if I wanted to, and she was willing, he would take me into the shop and teach me the machinist trade. I think it was the happiest day in my life when my mother came home and sitting beside me on the rear porch steps told me what he had proposed. I asked her what she thought of it, and she said that it was not what she thought, but what I thought that counted, explaining to me that it meant our separation for a time at least, and that if I made the trade, I must see it through to the finish; that I was selecting a life work and that she wanted me to be sure before I decided. Well, I decided in about a half minute and on the following day left home to make my beginning.

You probably know that a boy, at my age at that time, who had accomplished what I had up to that time, had an idea that he was already "some punkins" as a mechanic, and I didn't fear very much when I entered the shop. Such is human nature in youth, and some day I want to write the amusing and sometimes absurd things that I did, and tell some of the crazy ideas that I had the first year. I have laughed many a time over the happenings of those years, but the memory of my experiences had been of great help to several young fellows whom I have had the pleasure of teaching their trade.

After finishing in the shop, a position was offered me to operate a small water and light plant. Electric lights were just becoming popular in the smaller towns; electricity appealed to me, so I went to work. I followed operating, installing, construction, etc., until 13 yr. ago, when, to make a long story shorter, through the carelessness of a helper, a belt caught me and jerked my left arm off just below the elbow.

This occurred within the same year that everything I possessed was destroyed by fire, with no insurance, and my wife was an invalid of 4 yr. standing. I think that, although times may get hard and things go wrong, there never will be a darker day in my life than Dec. 20, 1905.

An invalid wife, two small children and a mother to look after; I was crippled; the firm I was working for were in such financial condition that I knew I could expect very little from them.

But I went back to the little old former home. There was the old house with the little old tumbled down shop. As I looked at it the words came back to me that spurred me in the beginning: "He can, who thinks he can." Surely a *just God* would not allow one of His creatures, because of no fault of his own, to be crushed to where he would be an object of charity. I didn't want my children to grow up that way. I must get out and get busy. I gave my wife half of our resources and came to Memphis to look for work.

No one wanted a one-armed man. He couldn't do anything, and besides there were about three men to every opening anyway. Some were very sympathetic; others were brutal in their refusals of work. I tried wiring concerns, machine shops, foundries, in fact everything I could think of. Nothing doing. Finally I had some little business cards printed. I gave my name and address. I stated on them that I could *do anything.* Across the top in larger letters I had this appeal, "I do not want to be an object of charity. Give the crippled man an equal chance with the other fellow, and *if his work is not right, don't pay for it.*" I put in all my time calling on people and leaving these cards. Although work was scarce at that time, I soon began to get my part of it and those who had refused me work began to offer me a job. My business was interfering with theirs, because, having no big rental and other overhead expenses, I could work more cheaply.

Things were getting brighter, but my wife's health had reached the point where I must give up and go back. There was nobody that would give me a job in the home town. So I had to *make my* job again. About the only thing in sight was painting and paperhanging. A friend finally agreed to pay me $1.25 a day to paint his house. This gave me a start. I soon had all the work I could do, painting and hanging paper. I have

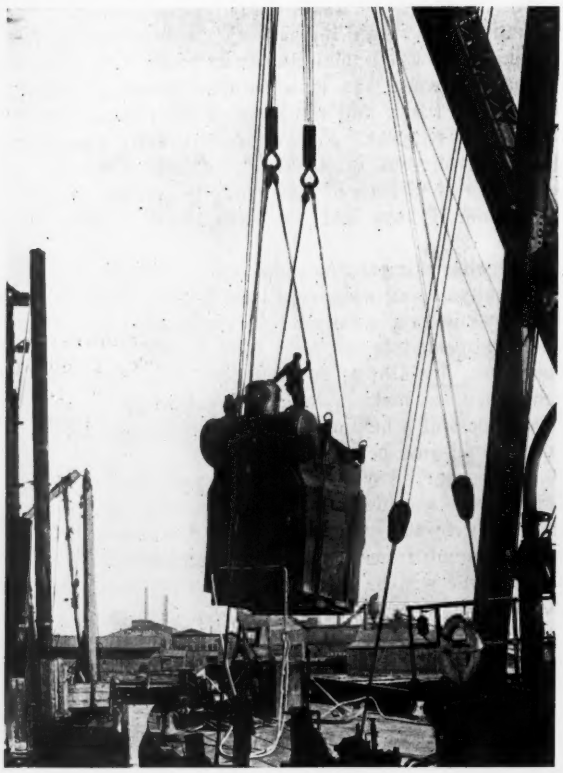


FIG. 1. LOADING COMPLETE BOILER ON LIGHTER

several times read the expression, "Busier than a one-armed paperhanger." Well, this applied to me all right, because I was busy all the time, and it was not on account of my handicap but because I did the work well, and always had trouble finding a workman to help me that could hang as much paper in a day as I could.

There was no plumber or sheet metal worker in the town. As I made more money, I branched out into this line, as it was more suited to my taste and talent. I made enough money in this line so that when we found a surgeon who told us it was a matter of an expensive operation for my wife to regain her health, I sold out the business and carried her to the hospital. This was very successful, although much more expensive than we had calculated. When I returned home with her, I was a little in debt, and had 60 cents in cash.

However, it had become the talk of the town what wonders I could perform, with one hand. I had no further trouble finding all the jobs I wanted. I have climbed poles doing line work. I have done every class of wiring that the Code provides for. I do my own repairing all the time on any kind of machinery. Were I to tell all the things that I have accomplished since losing my hand, it would sound like boasting and very few would believe it. I can, however, furnish affidavits from hundreds of acquaintances stating that I can do *anything mechanical or electrical.* It has been interesting to me and kept me from becoming disheartened, just to try to do the things that others said I couldn't do.

At present I hold one of the best and most responsible positions in this city. My present employers hired me on the testimony of previous employers. They did, when I first came here, ask me if I could do certain things, or suggest that *I have* them done. They never mention it any more.

But to those boys who are coming back scarred let me say, don't be blue over it. Any man with everything in his favor may accomplish anything, but it takes a MAN to make good when everything is against him. Remember, "He can, who thinks he can." If you were an engineer, be a better engineer now. If you were a

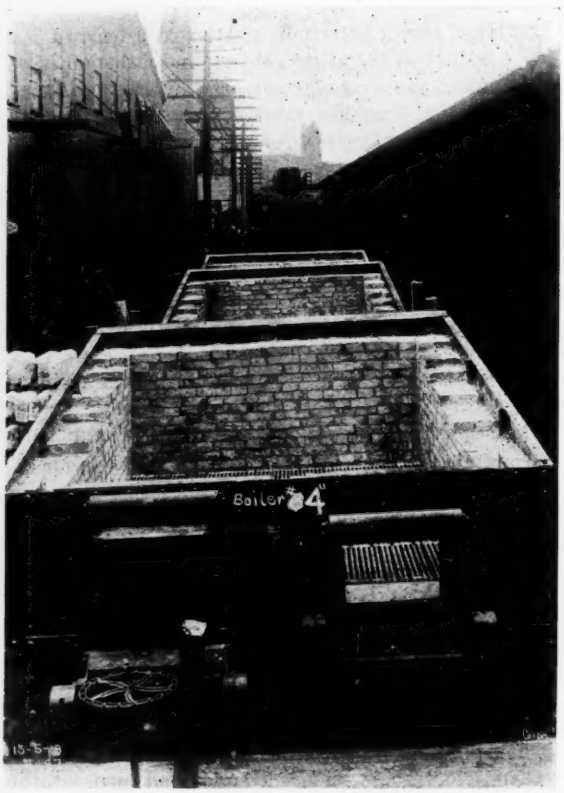


FIG. 2. FIREBOXES WITH LININGS LAID UP, ON CARS READY FOR SHIPMENT

painter, be a better painter now. No man is really crippled until the mind is gone. If I were to lose both hands and both legs, and my mind and tongue would still function, I would read and study until I could become so proficient in the knowledge concerning my trade that others would be glad to pay me for my lectures or writings. Don't give up, men, for you will get out of this life just what you go after, nothing more or less.

I will wind up with this old illustration. An old darky prayed nightly for the Lord to *send* him a chicken; but he had no answer. Finally he changed his tactics and prayed that *he be sent after* a chicken. He had the chicken for his breakfast.

Shipping Boilers Complete With Lining

TRANSPORTING boilers by water and rail completely assembled including linings is a new departure in boiler construction work.

This method of shipment was successfully accomplished by the Bridgeport Boiler Works in filling a government order for 12 marine boilers of the modified water-tube type, a smaller unit of the emergency fleet standard boiler. They are rated at 350 hp. and built especially for the 88-ft. government harbor tugs to operate safely at 150-lb. pressure. Each has 3-in. tubes and 4-in. tubes with a grate surface of 50 sq. ft. and a heating surface of 1800 sq. ft.

Shipment by water from Bridgeport to City Island, N. Y., was carried out by loading the completely laid up boilers on harbor tugs, see Fig. 1. On arrival at City Island, the boilers were then lowered directly into place in the hold of the waiting government tugs.

The boilers as shipped measured 13 ft. long by 13 ft. 6 in. high and 8 ft. 3 in. wide, weighing approximately 23 tons each. Figure 2 shows the firebox lining completed. The linings were laid up with high temperature cement furnished by the Quigley Furnace Specialties Co., selected on account of its strength, elasticity, adhesive and heat resisting qualities. It is stated that the linings withstood the handling in shipment successfully without even a crack, which speaks well for the material used and the workmanship.

Figure 2 shows fireboxes loaded on flat cars for rail shipment. Owing to their height it was necessary to load boilers and fireboxes separately. Destinations of shipments were as follows: Three boilers each to City Island, N. Y., Newburgh, N. Y., Camden, N. J., and Clayton, N. Y., the last named being the furthest point for rail shipment.

Operation of Marine Diesel Oil Engines*

METHODS OF REVERSAL EMPLOYED; LUBRICATION, HANDLING OF EXHAUST GASES AND COOLING. BY J. W. ANDERSON

THE method of reversing used on two-cycle engines is based on the fact that, in these engines, the spray and scavenger valves can be set right for running in the reverse direction by shifting the cams through a common angle. One camshaft running along the tops of the working cylinders operates all the valves; there is one cam for each spray and scavenger valve and the camshaft is shifted for reversing through an angle of 30 deg. The camshaft is shifted automatically by a slip coupling having a 30-deg. angle between the jaws, so that when the engine starts in the reverse direction, the crankshaft revolves 30 deg. before the camshaft starts, that is, when the timing becomes right for the new direction of rotation. The air starting valves are operated by two separate cams, one for ahead and one for astern, and the direction of rotation of the engine is determined by bringing into action the proper cam which in turn times the starting valve.

This automatic reversing mechanism fails to work satisfactorily when the engine is operated at low speeds, because then the engine does not turn exactly uniformly, and since the slip clutch is of the friction type, with jaws to limit the extreme travel to an angle of 30 deg., and since the camshaft and its parts have inertia of their own, this slip clutch fails to hold the camshaft in exact relation to the crankshaft. This upsets the timing of the valves, which in the case of the spray valve is important.

A similar method of reversing is used on four-cycle engines, but unfortunately it is necessary to have a separate camshaft for each kind of valve because of the different angles through which it is necessary to shift the cams in order to bring the timing right for the new direction of running. The engines are fitted with three camshafts, one for the spray valves, one for the inlet valves, and one for the exhaust valves. The air starting valves are operated by a single cam which is shifted by a separate mechanism to bring its timing right. Operation is pneumatic and the valves are controlled by plungers arranged radially around the single cam, in accordance with the proper sequence of cranks. All of the camshafts are shifted by means of a single pneumatic cylinder operating sliding sleeves, except for the addition of a set of jaws on the camshaft which register with jaws in the sliding sleeve in its extreme positions and take the driving effort. The work of the spiral grooves is thus confined exclusively to shifting the camshaft. As in the two-cycle engines only a single cam is provided for each valve. This method of reversing has been applied to several engines and acts as satisfactorily in the case of the four-cycle engines as for the two-cycle.

The method of starting a Diesel engine which is almost universally used is by means of compressed air, and in most cases the air enters the working cylinders.

In starting, the air is ordinarily turned on for only a few seconds and in a few seconds more the engine can be brought right up to full power if desired. In fact, with a perfectly cold engine, the operation will be a great deal smoother under a moderate load immediately after starting than it will be at a very light load. This applies particularly at low speeds. For stationary engines which operate at full speed only, this condition is not encountered because the engine is brought up to full speed immediately after starting and the flywheel has inertia enough to keep the engine running smoothly even though ignitions are somewhat irregular.

In a marine engine where it may be desired to start slow ahead or astern, which, with a small, light, high-speed engine is difficult, unless a clutch between the engine and propeller permits the engine to be started up independently, warmed up, and then the clutch

* Abstract of paper presented by author before Annual Meeting of A. S. M. E., New York City, Dec. 3 to 6, 1918.

thrown in. The trouble in starting up when the engine is connected directly to the propeller is that in order to get the first ignition the fuel is turned well on, and when the first ignition does come there is enough energy in the combustion to overcome the inertia of the parts and drive the engine up to a much higher speed than is desired. With large, heavy engines this tendency is not nearly so marked and it is possible to get a slow, smooth start.

There are several ways to assist in getting a smooth start on a cold engine, and it is important to follow one of them in the case of large engines. One method is to heat the jacket water by turning steam in from an auxiliary boiler. In this way the cylinder walls can be warmed up to something approaching the working temperatures, and a smooth start is easily made. Another method, particularly useful in installations where very heavy fuels are used, is to start with a lighter fuel.

Generally speaking, stationary engines and marine engines with clutches between engine and propeller are fitted with starting valves on only half the working cylinders. This means that while the engine is being turned over by starting air on part of the cylinders, the others are being warmed up by the compression, and even under very adverse conditions they soon reach such a temperature that ignition is obtained. In the case of reversing engines, the handling gear is sometimes modified to cause the starting air to be turned on and off the cylinders in groups.

The charge is often made against the Diesel engine that it is impossible to slow it down materially. This is true to a certain extent of the ordinary type of construction, but with the proper modifications any Diesel engine can be made to slow down and operate as readily at the lower speeds as at the higher. The solution of the problem consists in having a regular enough turning moment to keep the engine running fairly smoothly, and to obtain definite and regular ignitions in the cylinders. The case is much simpler for a large, heavy engine which has a big mass in the moving parts, and where there are a larger number of cylinders, say, at least six for a two-cycle engine and eight for a four-cycle engine, than it is for a small, light engine.

In the propulsion of a ship, the power drops off very rapidly as the revolutions are reduced, and therefore, at very low speeds, the power is so small that when divided up among all of the cylinders in the engine there is not enough fuel injected into each cylinder to give regular ignitions. This can be remedied in a large measure by cutting out half of the cylinders. The load per cylinder will then be more than doubled and the engine will run with very light loads at low revolutions.

Another method consists in the control of the spray-valve lift and timing by the operator. The control mechanism is so arranged that the timing and lift are changed at the same time. In some cases the valve is made to open at the same time under all settings and to close earlier, while in others it delays the time of opening by the same amount the time of closing is shortened. Both systems appear to work satisfactorily. When it is desired to slow the engine down, the fuel supply is reduced, the spray-valve lift reduced and the timing changed, and the spray-air pressure reduced somewhat. The combined effect of all these is to give regular ignitions in the cylinders, hence a smooth turning moment and good control over the engine.

The advisability of fitting some sort of gear for controlling the timing and lift of the spray valve depends upon the type of engine and the place where it is going to be installed. Without such gear, an engine can be slowed down to about half speed without difficulty, hence for installations of small power in ships having a maximum speed of 10 knots or thereabouts it is unnecessary, because half speed means little more than steerageway. On the other hand, in the case of ships having a higher maximum speed such as 15 or 20 knots, it is very desirable to be able to slow the engine down to quarter speed or less, and then the installation of such a gear becomes almost a necessity. Under some circumstances, of course, it might be considered better to sacrifice maneuvering ability for the sake of simplification, but on engines of the size used on seagoing ships, the slight added complication due to this gear seems every bit worth while.

Lubrication

The question of lubrication is one that is dependent upon the type of engine. The gravity system is used successfully on large, open-frame, slow-speed engines, while on the small sizes, particularly where the crankcase is enclosed, a mechanical oiler is often used with leads to separate bearings or else a system of forced lubrication. There is one difficulty with the gravity lubrication and the mechanical oiler, and that is that there are many parts and pipes to consider, and each pipe or lead requires a certain amount of individual attention in order to see that the proper amount of oil is being supplied to that particular part. Furthermore, with these systems only just enough oil with a slight margin is provided to cover the necessary requirements of the bearing.

The big advantage of the forced-lubrication system is that a good surplus is supplied to each bearing at all times and distribution of the oil is secured by the proportions of the various passages, and hence requires no attention on the part of the operator other than to make sure that the main supply to the engine is kept up. Of course the various passages must be kept clear and open, but this is a matter that can be readily attended to during the overhauling period, and there is very little tendency for the oil to plug up the passages during operation.

There is one thing in connection with forced lubrication that is extremely important and requires constant watchfulness on the part of the operator, and that is the question of salt-water leaks into the lubricating oil. Any leak into the crankcase, no matter how small, forms an undesirable mixture with the lubricating oil, and at moderate temperatures creates a deposit which will quickly plug up the passages. If special precautions are taken against the leakage of the salt water into the oil, and the condition of the oil is watched carefully at all times, there is little chance for difficulty in this direction. From every other standpoint forced lubrication has the advantage over other methods.

With an open-frame engine and using special precautions so that lubricating oil from the working cylinders does not drip into the crankcase, the oil does not

become foul except after long service, but with the closed-crankcase trunk-piston engine the lubricating oil soon becomes fouled with finely divided carbon particles. After a time the oil turns very black and viscous and tends to clog the oil passages. This requires as much as 3000 hr. running in some cases, while in others this condition obtains in a few hundred hours. It is understood, of course, that oil is added from time to time to make up for the losses, but the system is not cleaned out and the whole supply replenished in all this time. As this condition of the oil is approached the danger of bearing troubles increases, and if it can be avoided the oil ought never to be allowed to get into such a condition.

To attempt to filter or clarify the oil each time it is circulated through the engine would imply the addition of too much apparatus to take care of such a quantity of oil and, fortunately, it is unnecessary. The best way is to drain out the system at regular intervals, depending upon the type of engine and the conditions of the service, and fill up with fresh oil. The fouled oil can be filtered at leisure and kept for future use.

The usual method for the fuel system is to carry the main supply of fuel in the double bottom or in tanks in parts of the ship that are not ordinarily otherwise used, and then provide pumps for pumping it into gravity tanks placed well up in the engine room, so that the fuel can flow by gravity from the tanks to the engines. The tanks are made large enough to hold at least several hours' supply, and oftentimes a whole day's supply, so that the fuel has plenty of time to settle, and any sediment or water will collect at the bottom of the tank, where it may be drained off. It is very necessary that the fuel supply to the engine be perfectly clean. Very small particles of dirt or foreign matter will stick in the valves on the fuel pumps on the engine and cause no end of trouble. There is only one way to avoid getting this dirt into the engine, and that is to filter the fuel properly. The filter is sometimes placed between the gravity tank and the engine, and is sometimes combined with the gravity tank. In case the gravity tank is of small capacity, it is generally placed on the discharge side of the pump which pumps the fuel from the main tanks to the gravity tank.

The arrangement of the exhaust piping depends upon the type of the boat and the conditions of the installation. In the case of small boats, where the water line is more or less fixed and very little rough water is encountered, an underwater exhaust works out very satisfactorily, but in the case of large ships, the exhaust must be carried up a stack. In twin-screw boats it is essential that the exhaust from each engine be kept separate so that it can be watched by the operators. One of the simplest methods of detecting faulty operation in a Diesel engine is to watch the exhaust. The least sign of smoke is a sign of poor combustion and should be investigated at once.

Many varieties of muffler are used. Where there is plenty of space and weight available, a big expansion chamber serves fairly well, but it is much better to reduce the size and use baffle plates. One of the best types is one in which the gases enter a cylindrical chamber tangentially at the circumference and escape at the center, or vice versa. Cooling the gases by turning the cooling water from the engine into the exhaust pipe helps too, but is not used except in some special cases. If there is very much sulphur in the fuel, water combines with the products of combustion and forms sulphuric acid, which will in time destroy the exhaust piping. If, however, the entire quantity of the cooling water passing through the engine is turned into the exhaust, the mixture is so dilute that there is little danger of trouble.

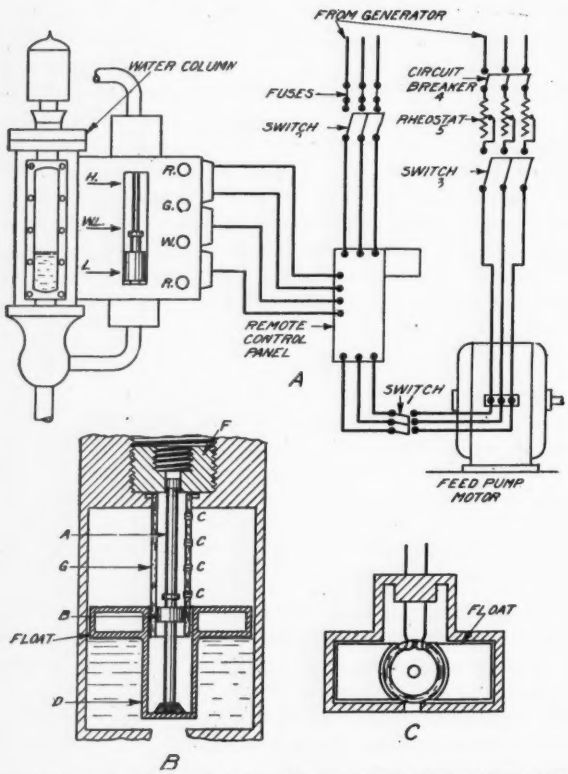
The question of cooling the various parts of a Diesel engine is an important one, but as far as the fixed parts are concerned the problem is simple for all ordinary sizes of engines. It is only necessary to provide for the proper flow of the cooling water, avoiding all pockets and dead areas. In the case of nearly all two-cycle engines and in four-cycle engines of quite moderate size, it is necessary in addition to cool the working piston, and herein lies a real problem. There is no exact dead line below which cooling is unnecessary and above which cooling is necessary, as a great deal depends upon the conditions of operation; that is, a high-speed engine designed to be driven at a heavy overload might require cooling, while the same engine driven at a lower speed and moderate power would operate perfectly satisfactorily with uncooled pistons. It is simply a question of carrying away the heat absorbed by the top of the piston. If it can be carried off fast enough through the cylinder walls to keep the center of the piston head from getting too hot, then the pistons do not need to be cooled, but if this is not so, then the extra heat must be absorbed by the circulation of a cooling medium through the piston. In general, it may be said that two-cycle engines developing 50 b.hp. or more per cylinder, and four-cycle engines developing 150 b.hp. or more per cylinder, are better off with cooled pistons.

The simplest method of cooling the piston is to employ a jet of air, but this is not very effective and can be used only where the cooling effect required is very slight. The other three substances employed to any extent are lubricating oil, fresh water and salt water. Lubricating oil has the distinct disadvantage that its specific heat is only about 0.4 of that of water, and hence about 2½ times as much must be circulated to carry off the same amount of heat within the same temperature limits.

For commercial work it is safe to say that the choice lies between fresh and salt water. Fresh water requires an additional system, including tank, pump, cooler and piping, but it is not so corrosive, not so destructive to the packing in the joints of the system, not dangerous as regards deposits in the piston, and in case of leakage into the lubricating oil there is not the danger of damage to bearings. When salt water is used with proper precautions, most of the advantages of fresh water disappear; but it is a question as to how far these precautions can be successfully carried out under every-day working conditions. Both fresh and salt water will undoubtedly be used for some time to come until enough experience is gained with both systems finally to settle the matter either one way or the other, or it may be that fresh water will be used for high-grade installations, and salt water where first cost and simplicity are of prime importance.

A Unique Water Level Indicator and Feed Pump Motor Control

In the accompanying sketch I have attempted to show in detail and assembly the construction and mode of operation of an automatic electric signal and control system for boiler feed pumps. The pump motor, as indicated, may be placed under manual control by means of the switch, 3, circuit breaker, 4, and rheostat, 5, or under automatic remote control, in which case the speed of the motor is varied according to the height of the water in the water column. With high water the motor



DETAILS AND ASSEMBLY OF WATER LEVEL INDICATOR AND FEED PUMP MOTOR CONTROL

is cut out of circuit entirely, while as the water level drops the motor is cut into circuit, and as it continues to drop, the speed is increased until a maximum is reached with the water at low level.

To accomplish this, the device shown in section at B and C is attached to the water column in the manner indicated. Essentially it consists of a housing containing a copper float to which is anchored a pilot rod, A, carrying a contactor, B, of copper of sliding fit with the inside of a glass tube, G. This tube, which has an internal diameter of 1 3/16 in. and walls ¾ in. thick, is fitted with terminal points c, c, c, c, in electrical connection with the remote control equipment. Each of these control circuits has connected in series with it a colored incandescent lamp, the upper and lower ones red and the two between each green.

As the water in the column rises it carries with it the float, which, coming in contact with the various points c, c, c, c, varies the speed of the motor, slowing it down on its upward travel and speeding it up on its downward movement. Simultaneously the signal lamps are brought into service, thus rendering it possible for the operators to determine at a distance the height of the water level.

Otto Dorthen.

Putting in New Pump Sleeves; Comment on Examination Questions

Seeing Charles Magnus' article on Putting in New Pump Sleeves, in May 1 issue, leads me to explain how we used to perform the same work, or, rather, gain the same end.

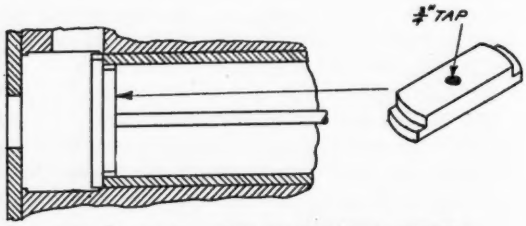


FIG. 1. PLATE USED IN PULLING SLEEVE

First, a workman was not allowed to cut out a lining, but was required to draw it. We found by experience that it was a very easy thing to cut the cylinder wall and so stopped this method of taking out the sleeve, but instead used the method herein described.

A plate similar to the one described in Mr. Magnus' article as to dimensions, but turned to fit the sleeve (as illustrated) was used as a pull jack. The hole in this plate is tapped for ¾-in. thread. The plate is slid through the sleeve in a horizontal position and turned vertically in the clearance space, then the rod is screwed in and the lining is pulled out. Two men, working on the same size pump, one cutting the sleeve, the other pulling, demonstrated that the pulling method was by far the quicker and absolutely the most practical way of doing the job. A pair of centers on an arbor was used for getting the proper size to sleeve should it be large, which was generally the case. The sleeve was fitted to slide in halfway and was forced with a false

head (turned to the inner and outer diameter of sleeve) the remainder of the way.

Should a sleeve be a trifle loose, we tinned it, but never roughed the cylinder wall to make it go hard. Some pumps were lined every 12 mo.; some would go longer; but every pump (and we had several of them) had its own set of tools, and these were kept in their proper places and could be on the job at short notice.

Referring to page 426, question 17, under Examination for Massachusetts Third Class Engineer's License, if the lead is the same on both ends of a vertical slide valve engine, we might expect the cutoff to take place at practically the same point; but if we give the bottom more lead by lengthening the valve rod, quite naturally the valve would close later and give a longer cutoff, regardless of whether it is a vertical or horizontal engine. The crankpin travels through a greater arc on the crank end part of the half stroke than it does on the head end half of the stroke, and this should have more or less to do with the lead of a slide or piston valve type of valve gear.

Question 30 is probably asked to get this same information, and perhaps the same cutoff on both ends may figure the same theoretical horsepower, but would it with a dynamometer or a brake?

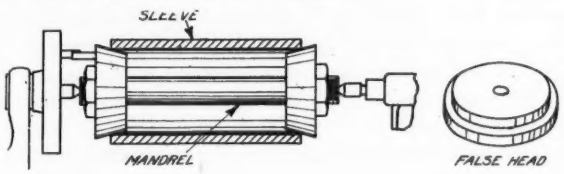


FIG. 2. MEANS FOR TURNING SLEEVE TO PROPER SIZE

In answering question 10—"Name all of the connections which should be placed on a long main steam pipe 8 in. in diameter, running from the boiler to the engine"—I would suggest that if this pipe is in a straight line, the first thing a genuine engineer would think of would be the expansion.

It has been my experience to see flanges on similar lines broken and more or less damage done by forgetting that steam pipe lengthens.

Perhaps this question may also have something to do with determining whether an applicant understands expansion or otherwise; if that is the case, it might be well to include an expansion joint in the fittings.

As to question 20, I would much prefer to disconnect the rod and push the piston back and forward to striking points marking crosshead, than to use the method described, for the reason that many times the nut on the end of the rod strikes before the piston. I have had this experience twice, and now prefer to test by disconnecting rod. TOM THUMB.

Feeding Compound Through Returns of a Heating System

HAVING EXPERIENCED considerable trouble from the wet returns of a vacuum heating system, due to pitting and corroding, and in the second year of operation having the pitting action well developed upon the tubes of the return tubular boilers with which the plant is equipped, the use of a suitable compound to counteract this action in the boilers becomes imperative. The thought naturally consequent upon the action was, "If this compound is good for the boilers why not for the system?" Several test pieces of pipe were cut out of the various runs affected and new witness pieces inserted therein.

There are 26 risers in the plant. At the end of the day's run a given quantity of compound is fed through the return line of one riser by taking off the cap of the thermo valve of the radiator on the top floor. With the vacuum pump maintaining a small vacuum the compound, well diluted, is fed through this opening and thus introduced to the system. Thus, in this particular case, the individual risers get a treatment every 26 days. Experience alone will determine the quantity that the particular system requires, as the taller the building the longer the run and the greater quantity of pipe to be treated. It will be found that a considerable quantity of compound will be used ere any showing is made of the compound reaching the boiler. I have operated on the above plan for the past four heating seasons and the witness pieces show a perfect coating of an enamel-like substance.

The same compound has a somewhat different effect as shown in its action (deposited) in the returns and in the boilers, which difference of deposit no doubt must be due to the differences of temperature, as the temperature in the returns would be about 212 deg., while in the boilers the temperature corresponding to 80 lb. gage equals 323.66 deg., which is the running pressure adopted in this plant, owing to having a self-contained installation; namely, high pressure pumps for handling return, steam actuated oil set and use of high pressure steam for atomizing the oil fuel through burners. Steam is fed to the system at a pressure of from 1 to 3 lb. per sq. in. through a reducing valve and a vacuum of from 5 to 8 in. kept upon the returns. H. GEAKE.

Amorphous vs. Flake Graphite

I'M UP against a solid proposition through an unintentional error I made in the last paragraph of the article on kerosene oil and graphite for boilers in the May 1 issue and would ask your permission to square myself. The paragraph reads as follows: "The kind of graphite suitable for such work is of the amorphous variety, ground to a very fine impalpable powder or it will not remain in suspension—." Now what I meant to say was that the graphite must be ground very fine —exceedingly so—and I used the word amorphous thinking it meant fineness, forgetting entirely that amorphous meant a certain grade of graphite. I shouldn't have used the word amorphous. I know better, too; but had forgotten my previous experience of years ago when amorphous graphite had caused me considerable trouble due to its piling up, balling up and clogging up propensities when used under certain conditions. Hence my using the word in that article was stupid of me and my engineer friends are beginning to sit up and take notice. Herewith is a copy of a letter received some days ago on the article:

Chicago, June 1, 1919.

"Say you old Backslider—what's happened? You've reversed yourself; see May 1 issue, Power Plant Engi-

neering, under Kerosene and Graphite. Since when do you advocate the amorphous kind for that work? Remember the trouble with stopped up dry pipe in those two boilers when you bet me $5 that it was the kind of graphite we used that caused the holes to plug up and I took you up and lost? And about the piling up in those air compressor valves and parts? Your suggestion to try the finely ground flake kind after clearing up process was followed and we got on "Easy Street" again. But why the change to amorphous? An explanation is due, or if you are right how have the people selling amorphous been able to separate the clay which in our opinion causes the trouble?"

To recite the trouble: Two boilers were fitted with dry pipes, no domes used owing to low headroom. (We did not have such a low opinion of domes at that time as we now have. We thought them O. K. in those days). Water was bad, scale formed very rapidly and they tried compounds, etc., with but poor success. Somebody advocated graphite be fed through open heater into boilers. They purchased graphite and it proved of amorphous variety. In three months considerable trouble was caused by continuous priming, clicking continuous in cylinders, pumps would run slow and groan, no amount of oil could keep boiler feed pump from groaning.

I talked with the chief and found what he was using in boilers to keep down scale. Getting a look at the graphite and lifting a handful, I was struck by its weight, which seemed to be considerably more than a handful of any other graphite I ever lifted. Then also the trouble they were having with an I. R. air compressor suggested investigation of the quality of graphite. They were getting short of air; compressor capacity had fallen off 20 per cent in a couple of months. The engineer had been in the habit, I learned, of throwing a handful of the amorphous graphite in the air intake pipe every day, sometimes twice daily.

I thought it over while lying in my bed that night and came to the conclusion that it must be the graphite in the boiler that caused the priming, but how it could was the puzzle. The water seemed good to drink and why it was not good for boilers was something I wanted to know and I experimented with an iron kettle over a hot fire in the yard. I boiled the water hard and threw in graphite. The water before putting in the graphite seemed to give off a scum with which the graphite readily mixed and floated around. I bet the chief $5 I had found the difficulty with his boilers priming; he took me up and eventually in three days lost, after we had found conditions as I predicted. That is, the scum and graphite gradually stopped up the holes in dry pipes and as only a few remaining holes had not plugged up, due to scouring action of the steam and water rushing out to engine, the local pull nearest holes unplugged caused water to be entrained and pass to engines giving very wet steam and its evils.

We opened up and sure enough, there was a heavy deposit all over the dry pipe and the entire surface of boiler at the water line was coated ½ to ⅝ in. thick with a blackish or dark brown deposit that had to be scraped off and all holes unplugged, caps of dry pipe removed and a tin cover nailed on a long stick in sections used to clean the dry pipe interior. All tubes on top were wiped clean, as there was a heavy deposit there too, and in all they removed a barrel of such mess from each boiler. The air compressor was found with all passages choked to a certain extent with a built-up coating of dense graphite and after cleaning everything, grinding all valves, etc, it was started up and all trouble was at an end.

I suggested getting the finely ground flake variety and using a smaller amount, which was done and the troubles had never returned. I kept in touch with the chief and we've worked together, and corresponded many times. The letter herewith is one relative to that job. At that time I did not know that graphite could be made so pure as it is now made by the electric furnace. I believe this development was not known 15 yr. or so ago when the occurrence as cited happened. My experience dictated, however, that the heavier amorphous graphite must naturally contain clay or other substance, causing the greater weight than that relatively possessed by flake variety finely ground, and then experiments with the amorphous supplied at that time showed me how it balled up, built up on surfaces and closed up ports, passages, etc., diminishing the cross-sectional area of such passage and naturally cutting down capacity to a certain extent, and the experiments made with finely ground flake graphite covering some months showed us that this kind did not have those properties, hence I've favored the ground flake ever since.

The amorphous graphite can be used in thousands of places around a plant. It is successful. I am not condemning it in any way *except* for internal lubrication of cylinder, lubrication of bearings, etc. Otherwise use it. I am not trying to boost any company making graphite. My mission is to pass my experience along to other engineers so as to lessen their burdens, to keep them from making mistakes and to avoid unnecessary troubles. I do not know how many companies make or market the flake variety of graphite, but it is certainly known that the flake graphite does not carry anywhere near the amount of impurities that the amorphous variety does.

I have used graphite for many places in engine rooms for many years. It will help any engineer out of tight places if used right, but use only small quantities. It can be used too freely and results spoiled.

Many other cases of balling up and clogging up could be cited, but this letter is too long now.

D. L. Fagnan.

Remedy for Steam Pump Trouble

We recently installed a small Marsh steam pump to handle our returns. Shortly after starting up, the machine went lame on one end of its stroke. After thoroughly examining the water end for packing troubles, jammed valves, etc., and finding all O.K. at that end, proceeded to open up the steam end. The first conclusion arrived at was that the packing surrounding the trip tube of this type of pump was slack or given out, which happening will allow one end to act lazy, and as the packing finally gives out, the valve ceases to function, owing to lack of motive power. The packing was found to be in good

shape, however, rod or trip tube all clear and all passages clean and open.

Upon pulling the valve gear apart, the following conditions were exhibited: A small "core spray" that had been overlooked in cleaning the casting had worked into such a position that the said "spray" was bearing heavily upon the valve spool. The spool happened to be in just that position whereby the small hole that is drilled through the spool (or strap) till communication is established with the axial hollow of said spool, was closed by the abrasive action of the valve rubbing against the "spray," causing a complete blockage of this hole and thereby destroying the balancing action. The removal of the cause and removal of the burr of this small hole in the valve spindle made everything all right again. Truly from little things arise great results.

P.

Division of Work

UNDER CAPTION "In Trouble," on page 520, June 1 issue, I note H. W. Rose's remarks.

It may be that Mr. Rose has had the night shift and did not just relish it, but if he were the chief, with a chief's duties and responsibilities, he would not talk of shifting runs for a week, month or any length of time.

Every institution, whether public, private or otherwise, must have a head who shall be responsible for the working of said establishment. An engine room must needs have a head too, and that head must be responsible to somebody higher up. It cannot have two heads and be successful and just the minute shifts are made that will alternate the hours of work between chief and assistant, trouble will develop.

The assistant, when he is on the day shift, feels his oats, as it were, and then trouble begins to brew. I know, for I have worked under these conditions, as the assistant.

In almost all plants, whether small or large, the shifts have their individual duties and more especially in manufacturing plants.

It was my misfortune, perhaps, to work in a 24-hr. plant some years ago and each shift worked 12 hr. *We worked!!* Operating the valve gear of engines developing hundreds, yes, into some thousands of horsepower is actual work when you have to do it sometimes four or five times an hour. The shift changed every week. It was the most miserable combination imaginable, but it gave us each an equal show even though it spoiled to a great extent the morale of the plant. There were some thirty-odd operating engineers and it really was a *regular* plant.

If the plant is generating electricity for sale and the load is more or less balanced, the shifts can rotate; yet if the said plant is not large enough to maintain an assistant engineer and boiler room engineer who shall be on the day watch, who is going to be responsible for the plant?

Don't have it in your mind that the chief engineer in a plant of any size can depend on all the force to keep things in operation at all times, for he cannot. Then if the plant has only its regular engine room and boiler room operators, one in each room must be responsible for the working of his department and he cannot work on the different shifts and still be in charge of his department. When you give a man the day shift as a steady run, it is a promotion. Now arises the question, "Why does the chief need a man in each department? Why doesn't he do the work himself?" and the answer will be found on page 523 of the same issue, under "Filling a Gap."

"A foreman or superintendent who must continually with his own hands do the work of his gang or his force is not the man to produce results."

There never was a truer line written.

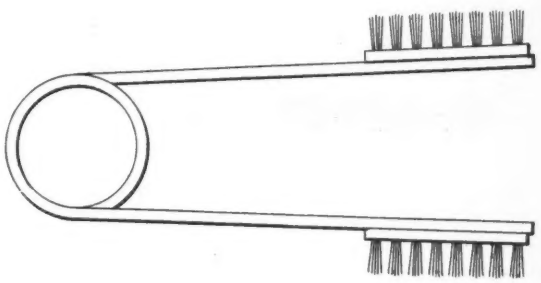
Let us not argue about the plant of say from 50 to 200 hp., as we know the chief will be short enough of men so that it will be necessary for him to do his own repairs; but let us rather consider whether it would not be better for the night man to get a job doing some other kind of work if he is not satisfied with his present position.

How many chief engineers have had the chance to pick at all times the kind of job they would like or the hours they would prefer to work?

TOM THUMB.

Cleaning Brush for Valve and Flange Threads

THE WRITER was once engaged in a construction job on which was used a large quantity of used and second-hand fittings and valves, and a considerable amount of



CLEANING BRUSH FOR VALVE AND FLANGE THREADS

time was being consumed in scraping out the various threads on the valves, flanges and fittings, which had become rusted up or filled with dirt or grease. After doing this with a sharp pointed file end for several days, we decided to rig up something to save time and labor, and devised the cleaning brushes as shown in the sketch, made up of two narrow wire brushes attached to a spring handle so that pressure would be exerted when released against the thread surface. This device worked out very well and paid for itself many times over in time and labor savings. Where any quantity of pipe fittings with old or second-hand material is done, it would be well worth while to make up a cleaner of this kind.

M. A. SALLER.

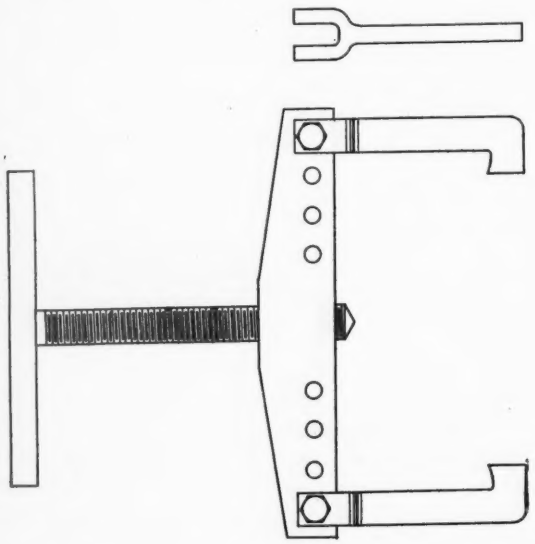
Adjustable Pinion Remover

ANY READER who has had occasion to remove pinions or pulleys from shafts will agree with the writer in saying that frequently such pinion or pulley is keyed in in such a manner as to render its removal difficult. For instance, in the case of a motor, the pinion of which has

in some manner become wet, the key will rust unless given the proper attention. Therefore if it becomes desirable to remove the pinion great difficulty will be experienced, first from the rusty key, and next by reason of the fact that the tool used in driving off the pinion must necessarily be held at an awkward angle to prevent injury to the winding or to the frame, as the case may be. There is also great danger of cracking the end-bell or of damaging the pinion by repeated blows.

Therefore, as there are so many disadvantages connected with this antediluvian method, the writer has constructed the tool shown in the accompanying sketch. This is adjustable to any reasonable size of pinion or pulley; that is, those having diameters of from 2 to 12 in.

To operate this tool successfully, the following is the proper course to pursue: Adjust arms in such manner that the inside dimensions will either correspond exactly to or be a little larger than the diameter of the pinion. Screw out the T handle as far as necessary. Pass arm hooks behind the pinion and screw T handle



DETAILS AND ASSEMBLY OF ADJUSTABLE PINION REMOVER

in until it fits snugly in the center hole of the shaft.

The tool is now all set and by simply screwing the T handle in the pinion will be gradually removed.

MAURICE S. CLEMENT.

Reclaiming the Pennies

BEING far too small to warrant employing a separate overseer for each department, many mills set up an individual known either as the chief engineer or master mechanic, among whose category of duties, besides the operation of the steam plant, are included the maintenance of every mechanical phase of the industry. His trials and tribulations are many and too often he is sorely underpaid. He has to contend with the most obsolete of equipment, heavily overloaded and in constant need of repairs.

He frequently asks for new equipment but is told that what he asks is an undreamed of possibility. His employers cannot afford it. They scarcely realize that with new equipment, even in part, dividends would be materially increased in the long run.

It is a hard and tedious operation to part a penurious mill owner from sufficient capital to re-equip a run down mill and a still harder job to make him understand that eventually he will derive an income from such an investment. In some cases he cannot see it; in others, he will not. The mill owner raves about production costs, wages and what not. It costs him altogether too much as it is to operate the mill without considering the outlay of thousands of dollars in new equipment.

During the war he was daily brought face to face with posters urging him to save and help win the war. Stress was laid upon coal and the mill owner launched a terrific drive in that direction. He was highly successful and he found that it meant lower operating costs. Still, while his efforts were all centered on his coal pile, waste, to the extent of many dollars each day, was going on in other departments of his mill; shameful, costly waste, with no effort being made to eliminate it. It will probably remain for some insignificant but enterprising chief engineer to point out this waste.

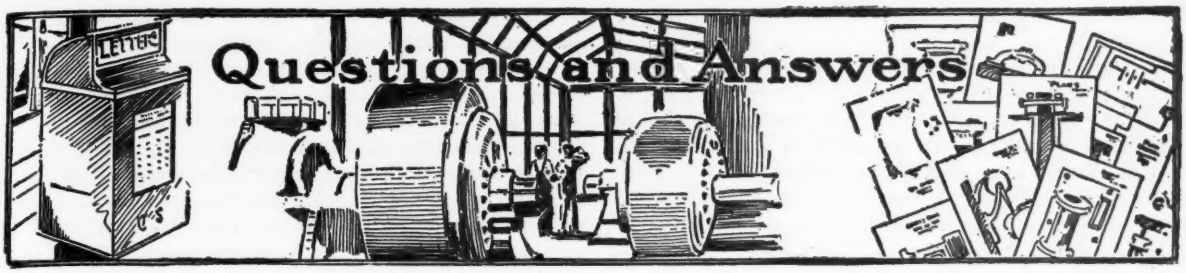
The mill owner has not seen this specter of insolvency following him around. He feels well satisfied with the patriotism he has shown in saving coal and thus helping to win the war; but if he would only dig a little deeper instead of patting himself on the back, he might be in a fair way toward actually finding money enough to buy at least *some* new equipment.

Let this mill owner employ an intelligent man to reclaim waste material. Let him order the man to save every scrap of material possible and base this man's wages on results. Thus he will be put upon his own initiative and if there is an ounce of brains in his head, he will make good. Let this man collect such things as iron, brass, copper and bronze cuttings from machine shop lathes and pipe and bolt threading machines. Have babbiting and lead work done where nothing will be wasted and lost. Remelt scraps of babbit, clear off the dross and pour the babbit into a homemade mould. The same with the lead.

Save every scrap of iron, copper, brass or bronze wire whether bare or insulated. Pick up rusted iron bolts, screws or nails. In short, old iron pipe or the thousand other commodities used in the every day mill. Search the mill from top to bottom and when once finished, start all over again. Then start to work and sort everything into piles by themselves. Those piles which can be used again should be so disposed of; but credit should be given for their reclamation. What is absolutely worthless as far as use is concerned can be sold for top junk prices.

At the end of the year, let the mill owner figure up what he has saved in this manner and see how much new equipment it will purchase.

Go into any large manufacturing concern and see what they are doing in this line to cut operating costs. In some of them, the business of reclamation has become almost a profession; and it certainly must be worth while or such important firms would not tolerate it for a day. Where you find the utmost in economy and efficiency, there you will also find salvage and reclamation working hand in hand. JOHN WALLACE.



Brick vs. Steel Cased Boiler Setting

OPINIONS as to the difference in efficiency between a brick set boiler and a steel cased boiler are desired. We would like as much information as possible on this subject. H. W. J.

Why This Noise?

WE HAVE a water system installed in a residence with the meter in the basement. There is a continual hissing sound all the time just like escaping water or air. The owner has applied to the Water Department to see if they knew the cause, but it is beyond us to figure out the cause, as everything seems all right.

If any of the readers of Power Plant Engineering could give us any suggestions as to the cause, it would be greatly appreciated. T. G.

How Can He Cure His Leaky Tubes?

ANY INFORMATION which some of the readers of Power Plant Engineering may be able to give me as to the manner in which I might eliminate the troubles enumerated below will be greatly appreciated.

I have in my charge a 60-hp. boiler of the locomotive type which, with the exception of the water legs, has brick side walls and a cast-iron front the same as any regulation return tubular boiler. The fire box is 3 by 5 ft.

The tubes leading from the fire box to the combustion chamber are 4 in. by 5 ft. and every three or four weeks, due to leakage, we must have the tubes rolled. I know the boiler is overloaded, and this, coupled with the fact that it is forced by means of a forced draft blower, leads me to believe that unequal contraction and expansion are responsible for the continued leakage.

When leveling, coaling or shaking down the fire, we lose about 10 lb. of our pressure within 3 to 5 min. How can I overcome this trouble?

Our engine is a 30-hp. Dunigan & Swift self-contained unit and when the boiler is so filled that the water enters the feed and well pumps, the engine continues to run full speed without a knock. The steam main from boiler to engine is 3 in. in diameter, however, reduced to 2 in. at the engine.

What would you say is wrong? T. H.

Better Lubrication for Oil Engine

To T. C. P., WHOSE REQUEST for assistance appears on page 519 of the June 1 issue, the following information may be of value.

From the data given in his article, there seems no doubt that not only is he using an incorrect grade of lubricant, but he also is using so much of it that carbonization takes place. *Carbonization will take place* with even the *best grades of oil* in use, if *overfeeding* of that oil is practiced. If an inferior grade of oil is used, then in order to have the correct oil film between the parts where friction takes place, a superabundance of oil must be fed and of course this is followed by carbon deposit. If a correct grade of oil be used, it will produce and maintain the necessary film with much less oil fed, and so the carbon deposits will not occur, or in a lesser degree with regard to quantity and time period, if at all. Thus the trouble can be kept at a minimum and coped with by a reasonable amount of care.

In the type of engine to which T. C. P. refers, the oil should be applied by a positive force—feed lubricator to each cylinder at three points, spaced equally about the circumference of the cylinder. This means continuous lubrication, but with control of the quantity of oil fed in any given time. A high grade, heavy body oil should be used for the desired results. A light body oil will not provide the necessary film between the piston and cylinder walls, and, as well it will not produce the necessary piston seal, so important in oil engine operation. By "heavy body" I do not mean the most heavy body oils that are made, for if the heaviest body oil be used it will not spread, and the frictional resistance of the oil itself will be high, and any impurities present will cling to the oil and break into a hard, crust-like substance. Moreover, a light body oil will not do, for it will break down under the influence of the high temperature in the cylinder, and there will be no seal. This is followed by excessive wear of the rubbing parts, and deposits occur containing a large percentage of iron, and cylinder oxides are formed, and then of course trouble ensues. With high grade oil, of the correct body, less will be required to maintain the lubricating film, and the piston seal, and so less wear takes place, and it will take a longer time for deposits to occur if at all.

Sometimes impurities in the fuel mixture accentuate any tendency toward the formation of deposits. This matter also should be looked into.

Only by the use of a high grade oil of proper body, applied in the way before referred to, in the proper places, and in the right quantity, can T. C. P. expect relief from the trouble he is now experiencing. I would suggest that he seek counsel from a recognized company selling lubricants, and talk to them along the lines suggested in the foregoing. His troubles can be cured, and when they are, it would be interesting to hear from him again, as to just what he did, and as to results.

CHARLES J. MASON.

I BELIEVE that if T. C. P. will use a heavy tractor oil in the cylinder, about one quart in 10 hr., he will

find it well lubricated, and his troubles from clogged ports eliminated.

I have experienced the same trouble with a similar engine and overcame it by cutting down the amount fed to the cylinder, and find it well lubricated. If the pump supplies oil to both cylinder and crank, I would suggest that he use about 2½ qt. per 10 hr.

He should also make sure that the oil drain from crank case is open and that the crank case is kept drained; also that there are no obstructions in air pipe or air valve.

ROYCE MOSER.

AFTER carefully studying the conditions noted by T. C. P. in his oil engine lubricating problem, I believe his trouble may be analyzed as follows:

Carbonizing of both inlet and outlet ports is caused by an improperly proportioned mixture of gas and air going into the cylinders. This may be corrected either by reducing the amount of gas or increasing the air; in other words, his mixture is too rich. His inability to secure a satisfactory lubricating oil can be answered in the following manner: First, his engine may be overloaded; and, second, if his air compressor is not working properly and the heat of his cylinders should be excessive, it would give lubrication trouble. The water jackets should be thoroughly cleaned to assure a perfect circulation around the cylinders.

It is assumed that the valve setting and magneto timing is correct. If the engine is timed a trifle late instead of at the correct firing point, quite a number of almost inexplainable faults may result.

The most important data necessary to diagnose thoroughly this problem, which T. C. P. has neglected to give, is the kind of centrifugal pump he is operating; whether it is vertical or horizontal, and the number of impellers or stages.

I am of the opinion that all of his trouble is not caused by his engine, but is due to the fact that he has the wrong kind of a pump for the work to be accomplished. He should base his calculations in the size of the pump for 300 g.p.m. as follows: Provide a 4-in. suction, a 3-in. discharge, which would average about 0.22 hp. for each foot of elevation.

With a three-stage pump, I believe that he would secure more satisfactory results, and reduce his engine oil consumption to a minimum; however, where a practical engineer is operating the engine pump, satisfactory results can be obtained at a normal cost by using a two-stage pump. In my opinion, it is almost an utter impossibility to obtain the required results with a one-stage pump for a 180-ft. head.

H. W. ROSE.

Cylinder Lubrication Trouble

IN REPLY to E. C. F., page 473, May 15 issue, the oil is carried back toward the separator with the reversing of the flow of steam because the speed of the engine cutting off 600 times a minute causes a sudden kick back. I see only two things that he can do: Either move the separator farther back from the engine, or else disconnect the steam line farther back from the separator and make a "dummy" flange 1 in. or smaller than the steam line to the engine and put it between standard pipe flanges. Of course, he could determine more about the size by indicating the engine; and if the largest load on engine will permit, he can, of course, make the hole smaller than 1 in. of the pipe, the farther away from engine the better, as it would still give him the excess pipe size and separator to fill up the cylinder quickly and maintain high initial pressure. This will also cut out any pipe vibration if he has any. This very thing, according to my notion, is blamed for high admission on cards as much as rod angularity, as we are taught to believe. I should like to see some of E. C. F.'s cards reproduced in Power Plant Engineering, or to ask him if his cards have not a very pronounced high end.

I have seen steam line oily and inside of dome also oily from this same trouble, for the boiler was fed with an injector, and in no other possible way could oil get into boiler.

FRED V. BROADAWAY.

Lubrication With Superheated Steam

I WOULD LIKE to take issue with G. R. Aphite, page 474, of the May 15 issue of Power Plant Engineering. He says: "If lubrication with superheat is to be accomplished, there remains but one way to do it effectively, and that is through the judicious use of chemically pure cylinder lubricating graphite."

I take issue because there are numerous reciprocating engines in this country where 250 deg. of superheat is being successfully and effectively applied without graphite.

It is a fact that the question of lubricating reciprocating units using superheated steam has been one of the main reasons why superheat has not been more generally adopted in this country. This problem has been solved, however, and by education will eliminate any reflections which may work against the more general adoption of superheated steam.

In foreign countries, the use of 800 deg. F. is common practice in engines, particularly of the piston valve and poppet valve types. These types naturally lend themselves to high degrees of superheat.

Good practice dictates that oil from the sight feed oil pump (or its equivalent) should be led to the middle of the pipe where the steam velocity is greatest and by means of an atomizer broken up into a spray and evenly distributed. Feed lines to the valves as well as to the cylinder are desirable. In piston valve engines, more lubricant is required for the valves than for the piston and rings. With this method, a cylinder oil having a lower flash point than that of the temperature of the superheated steam may be used. This is possible, because, while the flash point is determined at atmospheric pressure, it will require a higher temperature to flash under the steam pressure in the cylinder.

LU B. CATOR.

Allowable Back Pressure on Engine

AS I WISH to utilize exhaust steam for heating purposes, I would appreciate learning from you the amount of back pressure I might carry on an 18-hp. slide-valve engine. I am already carrying 5 lb., but would like to increase this if possible.

The boiler pressure is 80 lb. A. D. R.

A. We do not believe the back pressure on your engine could be increased appreciably without a decided loss of power. Ordinarily, the loss of power is nearly proportional to the ratio of the back pressure to the mean effective pressure.

Of course, there are two ways of offsetting this loss; one by raising the initial pressure and the other by increasing the cutoff. Engines are usually designed to work most economically at a given cutoff, so that in most cases it is undesirable to change it to any extent.

Computations for an engine having a clearance of 5 per cent, using 80-lb. steam and cutting off at ¼ stroke, show that raising the back pressure 3 lb. calls for a corresponding increase of 5 lb. in the boiler pressure to maintain the same engine horsepower.

As we believe a pressure of 5 lb. should prove ample to circulate steam through any well-designed heating system, even of comparatively large size, the increase of back pressure calling for a higher boiler pressure scarcely appears justified.

Air Requirements for Combustion

How MAY I determine the amount of air required to burn a pound of fuel? 2. How many heat units are required to raise the temperature of 1 lb. of air from 70 to 2000 deg. F? N. C. D.

ANSWERS

LETTING A represent the weight of air required per pound of fuel, C, H and O the proportional part by weight of carbon, hydrogen and oxygen in the fuel, the value of A may be readily determined by means of the following formula:

$$A = 34.56\left(\frac{C}{3} + H - \frac{O}{H}\right)$$

When the flue gas analysis is known, the air actually supplied may be approximately determined from this equation:

$$A = 3.032\left(\frac{N}{CO_2 + CO}\right) \times C$$

Where A is as above. N. CO and CO_2 the percentages by volume of nitrogen, carbon monoxide, and carbon dioxide in the fuel, and C is the proportional part by weight of carbon in the fuel.

2. In raising the temperature of one pound of air from 70 to 2000 deg. F., the required temperature rise is equal to 2000—70 or 1930 deg. F. Air has a specific heat of 0.2375, so that the total heat required would be equal to 0.2375 times 1930, or 458.38 B.t.u.

Electric Power Calculations

1. I HAVE a 5-hp. motor on a 220-v circuit, running 24 hr. How many kilowatts does it take to run it 24 hr.?

2. I have a 10-hp. motor on a 110-v circuit running 24 hr. How many kilowatts does it take to run it 24 hr.?

3. I have a 1-hp. motor on a 110-v. circuit. How many kilowatts does it take in 18 hr.?

4. I have 100 lamps, 25 w. each, burning 18 hr. a day. How many kilowatts does it take to run them? They are on a 110-v. circuit. T. R.

ANSWERS

IN THE following solutions to the problems submitted, we wish to call your attention to the fact that our calculations are based upon the rated capacity of the machine.

One electrical horsepower is equivalent to 746 w., so that a 5-hp. motor, when operating at rated capacity, will require 5 times 746, or 3730 w., or 3.73 kw. For 24 hr. this would represent an expenditure of 24 times 3.73, or 89.52 kw.-hr.

2. The second problem is, of course, solved in a similar manner, only that instead of using 5 hp., we use 10. Under those conditions, the energy requirements would be equal to 10 times 746, or 7460 w., or 7.46 kw. For 24 hr. this would require an expenditure of 24 times 7.46, or 179.04 kw.-hr.

3. One horsepower motor, as we stated above, requires 746 w., or 0.74 kw. For 18 hr. this motor would require 18 times 0.746, or 13.42 kw.-hr.

4. Each of the lamps referred to has a rating of 25 w., so that for the 100 lamps there would be required 100 times 25, or 2500 w. This is equivalent to 2.5 kw., or for 18 hr., 45 kw.-hr.

Gasoline Engine for Light and Refrigeration

WOULD IT be practicable to install a small electric lighting and refrigerating plant to be operated by means of a gasoline engine? This would be for use in a country store. R. B. M.

A. It would be entirely practical to drive a small electric light and refrigerating plant with a gasoline engine. The only question in regard to this would be whether it would pay. Gasoline is rather expensive for fuel, and while for small amounts of power, in a place where electric current is not available, it may be the most practical method, there is always a question whether the return will pay for the investment and operating cost.

The gasoline engine, under this kind of a load, will run with very little attention, but it will take approximately a pint of gasoline per hour per horsepower.

If you can give us some idea of the amount of lighting that you wish to do, and the capacity of refrigeration required, we could then tell you somewhere near what it might cost.

It is probable that, with this kind of a load, you might find it advisable to use a kerosene engine rather than gasoline. Kerosene does not work particularly well where there is a load that varies widely; but for refrigeration and electric lighting, this would not be the case, and we believe a kerosene outfit could be found which would work very well.

Radiation Losses for Uncovered Pipes

CAN YOU give me a table which tells the radiation of different size pipes or the radiation per square inch of surface? A. B. V.

A. Radiation losses for uncovered pipe are given by,

$$Q = A\ (T_1 - T_2)\ U$$

where A equals square feet of radiating surface, T_1 equals temperature of steam within the pipe, T_2 equals temperature of outside air, and U equals transmission coefficient equals 2.7 B.t.u. per square foot per hour per degree of temperature difference.

For 1 in. magnesia, 85 per cent, U=4.4 —0.5.

For 1½ in. magnesia, 85 per cent, U=0.25 —0.3.

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What Prospect?

One question which is of greatest concern to all of us is, "What is to be the trend of prices?"

It would indeed be a daring man who would make a positive prediction as to how greatly or how rapidly prices will change, though the general expectation is that they will decrease.

Many leaders of industry believe that the lowering of prices will be reduced gradually, the reduction extending over a period of 5 to 10 yr., but never reaching the level of pre-war prices. This is based on the fact that during the period of 1864 to 1874, even with the change from hand methods to machine methods in industry the drop in prices was at the rate of less than 6 per cent a year. This was in addition to a 25 per cent drop, during the first 5 mo. after cessation of the Civil War. But, during the 5 mo. from Nov., 1918, to Apr., 1919, there has been a price drop, on 92 commodities of common use, of from 5 to 6 per cent. And there is now in prospect no such opportunity for cost reduction as was presented by the general adoption of machinery to replace hand labor.

We all want to see the prices of things we buy reduced; we are not so anxious to have the same tendency in things that we sell, including our labor. There seems to be no evidence that in essential commodities there is at present any undue margin between cost of production and selling price. In other words, there is no indication of excessive profits being made by manufacturers. If prices are to be reduced, therefore, costs of production must be reduced, and it is worth while examining the factors that may have an influence in bringing this about.

Fundamentally, on a free market, price is regulated by supply and demand. If more articles are wanted than are available, buyers will bid against each other, and prices will rise. That has been the tendency during the war, with respect to both materials and labor. But the free market has been modified by government control of prices with two ends in view; first to prevent competitive bidding from forcing prices of materials unduly high; second to establish a price high enough to ensure maximum production of those materials for which a sudden large demand made it necessary that productive capacity be increased.

When the supply of an article exceeds the demand for it, either because of an accumulation being thrown on the market, or because production is more rapid than consumption, prices will fall, because buyers are scarce, and sellers trying to increase sales will bid for customers.

The government now has large stocks of various commodities, bought in anticipation of a longer war, for which it now has no use. If these were thrown on the market at once, it would probably "break the market," and prices for those commodities would drop sharply—perhaps below the cost of production—interfering with the business of manufacturers, and probably causing shut downs and unemployment.

To avoid this, the effort is being made to dispose of surplus stocks slowly, either through open selling or the regular channels of trade. To some extent, this is delaying the settlement for government contracts, thus tying up capital of manufacturers, and interfering with production, but probably to a less extent than would the

immediate throwing of all surplus stocks on the market.

Evidently it is not desirable that production should be stopped. That would mean lack of work and hardship. So the effort of the government is to be commended. But it remains to be seen how far it will succeed.

The effort to stabilize prices by agreement between the government representatives and conferences of the larger manufacturers is not meeting with marked success, nor is it securing the co-operation of those in government positions who control buying. Their effort has been to buy below the agreed prices, and this has reacted on the action of private buyers, causing a delay in placing orders, in the hope of buying cheaper. Government expenditure has been high. There is a feeling that it must be reduced in order to permit lower taxes; and from this viewpoint the effort of government officials is wise. But cost of living is still high, even shows in some items a tendency to increase, and any lowering of wages is undesirable until living costs show a downward trend.

High labor cost means that prices must be high, for in most lines the labor item is at least 75 per cent of the total cost. On the other hand, continued rise of labor cost;—i.e. rise in wages,—must result in still higher prices, and so far as this takes place in the field of common necessities of life, a still higher cost of living.

If prices are to become lower, there must be lower labor cost per piece, and the best prospect for accomplishing this is by increased production per hour of labor. Attempts to curtail production are therefore a direct means of increasing prices and the cost of living, are a distinct disservice to the country and the people, and should be condemned by all right thinking workers.

Another reason for encouraging increased hour production is that we have reached the point in our industries where our manufacturing capacity is greater than the needs of our own people. To keep our factories busy we must sell abroad. Since our standard of wages and living is higher than in those countries with which we must compete for export business, the cost of production must be equalized by greater product per hour worked. If this is not done, the wages paid per hour must be reduced in order to get export business. And if our production costs are not put on a basis where we can meet foreign competition, we can protect our own industries by means of a high tariff wall to the point where our own needs are met. Then manufacturing must cease, and industries stop growing.

It is conceded that prices will not fall to a prewar level anywhere in the world, because credits have greatly increased and there is more money in the world. (Money represents the credit that a man has against the accumulated wealth of the community.) And the standard of living, especially in this country, has risen. But, if commodity prices and cost of living and hours of work are to decrease, the hourly output must be increased. And if our industries are to continue to expand, which is essential for "good times" we must seek earnestly for lower production costs on which our success in enlarging export trade will depend.

Not lower wages, except as justified by lower cost of living, but increased production, more business, cessation of disturance of manufacture and lower cost of production should be the prospect for which we look and strive.

The Cavalry of Industry

During the war, we heard much of the man in the shop serving as much as the man in the army. But we did not get specifications as to the branch in which he served. A little consideration places him in the cavalry, for every man is using horsepower—some many horsepower—to do his work.

Just a few facts. It will take continuous effort of a big draft horse for 1⅓ hr. to give the energy of a kilowatt-hour. And a horse can do as much muscular work as 10 men.

Now, in the Schenectady shops of the General Electric Co., over 66,000,000 kw.-hr. of electric energy were used during 1918. And the employes, men and girls, were 21,500.

There you have each man and each girl, on an average, using 3100 kw.-hr., or about 4150 hp.-hr. On a 9-hr. day basis and 300 days a year, each employe was using one big draft horse and one ordinary horse, truly some force of cavalry. Practically an army division and each one with two horses to ride. Of course, some of the girls used only a pony, so that left some of the men using a team that would put into the shade the 20-mule borax outfit.

Now look at the men it would have required if this cavalry outfit had been infantry—all man power. That 4150 hp.-hr. would have required the muscle work of 15 men working for each employe. Each employe commanded the labor of two infantry squads,—every working minute, all the year. The whole would have made an army of 344,000 men; and that in one works of one company.

What does it mean in cost to be using this industrial cavalry in place of men? With workers paid the average wage, the cost of electrical machinery and supplies is about 1/16 what it would be with man power used alone. An electric light socket instead of 30 cents would cost $4.80 if our cavalry force were wiped out. An electric toaster would cost $75, and a fan to alleviate our swelterings would cost $150. We would go back to kerosene and candles in a hurry.

And we would walk, or creep along in the festive horse car. Big factories would be out of the question. Small shops with a few men working would take their place. For most of us it would be a case of "back to the land." And for many a case of "no job."

To our cavalry of industry and its horsepower equipment, and to the resulting ease and low cost of production do we owe all our comforts and much of our civilization.

THE COMPETENT engineer does just enough at the proper time to keep his engine in shape, without everlastingly tinkering with it. He watches for any unusual action that may indicate likelihood of coming trouble, and listens for unusual noises, and tries to determine the cause. But don't tear into your engine merely to see if everything is all right; if it isn't, you will soon be given notice, and it will then be time to make an inspection.

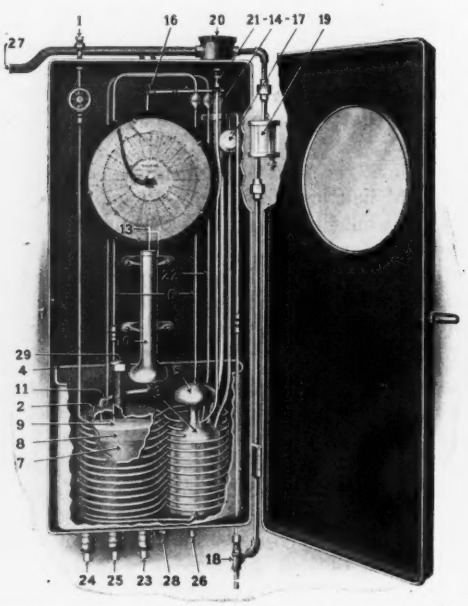
When you do take the engine down for general inspection and overhauling, make a thorough job of it from one end to the other, and you will find it money saved in the long run.—J. E. PORTER.

A New Automatic CO_2 Recorder

THE instrument shown herewith is in reality an automatic recording Orsat. A solution of caustic is used for a reagent, and the motive power is obtained from a constant flow of water and the periodic operation of an automatic syphon, the amount of water required per day being approximately 2 bbl. There are three moving parts, the clock movement for rotating the chart, the pen-actuating float, and the dotting mechanism.

Frequency of analyses is governed by the operating period of an automatic syphon, which is regulated by a valve in the water-inlet pipe. The instrument functions satisfactorily for any number of analyses up to 30 an hour.

The caustic solution can be renewed without difficulty. The only part of the instrument which has to



INTERIOR AND PARTIALLY SECTIONAL VIEW OF NEW AUTOMATIC CO_2 RECORDER

be removed is the filling cap. The old solution can be completely removed from the absorption vessel by opening a valve at the bottom of the instrument. To obtain the right amount of pen-travel, it is necessary that the caustic solution and oil be at exact levels in the absorption vessel; and to make the filling as simple, accurate, and as nearly fool-proof as possible, the overflow method is used. All moving parts, stuffing boxes, and sights have been eliminated from the absorption vessel, insuring a tight gas chamber.

Lag in the instrument is negligible, the only appreciable amount being that induced by the gas-sampling pipe to the furnace. As the residue and unused gases are removed and the pressure in the instrument is balanced immediately after each analysis, there is nothing left to cause a lag, and any change in draft does not affect its accuracy.

The instrument is supplied in a cast-iron case finished in baked black enamel, and has improved features, such as automatic self-centering chart holder, interchangeable clock movement with three-point support, improved fountain pen, etc. It is designed for boiler-room installation, and if the full value of the instrument is to be realized, it should be placed where the fireman may see the records they are producing.

As previously stated, the instrument is operated by a constant flow of water, which enters through inlet pipe 1 and flows through the coils surrounding absorption vessel 2 and measuring vessel 3, submerged in water tank 4. The water passing through the coils equalizes its temperature and that of the water in the tank, maintaining the mechanism and the gases at a practically uniform temperature.

The water flows through the coils into measuring vessel 3 and traps a definite volume of gas in bulb 5, forcing it over through tube 6 to absorption vessel 2, where it bubbles up through caustic solution 7, which almost instantly absorbs the CO_2 gas present. Above the caustic solution is a layer of oil 8, and above that is gas chamber 9. A float tube 10 terminates in tube 11, which extends through the oil almost to the level of the caustic solution. Pressure in chamber 9 causes oil to flow through tube 11 into float tube 10, which encloses a float, to the upper end of which is fastened pen 13. The distance the pen will rise depends upon the quantity of gas forced into the gas chamber by the rising water—the gas reaching the gas chamber being the residue of the original sample after CO_2 is removed. The water rising in water-float tube 14 raises a float which operates dotting mechanism 16, causing the pen to press against the chart.

The water now syphons out through 17, and, as the syphon takes water away faster than it is delivered, the float in 14 drops, releasing pen 13. As water continues to syphon out, the pressure in the gas chamber decreases and eventually balances to atmospheric pressure through exhaust pipe 22, the float in tube 10 dropping to normal position. Water passing through the syphon operates aspirator 18, creating suction through water seal 19, and draws flue gas through the chamber of filter 20. Part of this gas is drawn through the filter into measuring vessel 3 through intake pipe 21. When syphon 17 breaks, the pressure of the gases in measuring vessel 3 balances, and the cycle is resumed by the rising water trapping the unit quantity of gas in bulb 5.

CONCRETE CONSTRUCTION, which has shown such marvelous development during the past two decades, promises an ever increasing demand for men, as new construction work of all kinds is being planned everywhere for the so-called reconstruction period. Only a few men have chosen this course under the direction of the Federal Board for Vocational Education. One of these is a carpenter, who lost his right arm in France, and is now in training under the Board's direction with a firm of architects in mill and factory construction. He is specializing in reinforced concrete forms and structural steel buildings. The Board anticipates an increase in the number of men who choose this course, as it offers work that is well worth while.

WOOD can be utilized to best advantage in a dwelling or apartment house heating-plant, or cook-stove, by burning it in combination with coal.

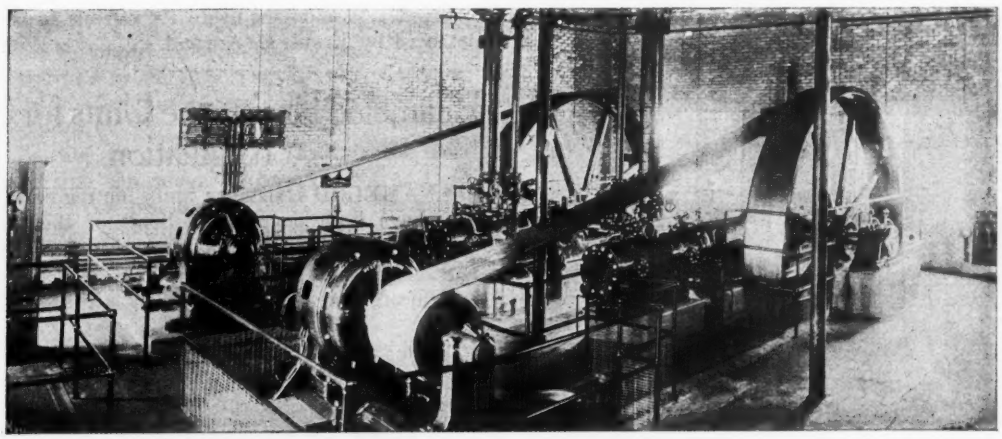
Induction Motors in Raw Water Ice Plant

THERE IS a general belief that the ice supply of the city of Duluth, Minn., is secured by weighting down large cakes of ice and sinking them in Lake Superior, where they are preserved indefinitely until wanted. That this story is a press agent's yarn is conclusively proved by the success of the Duluth Ice Co., whose plant employs ice machinery driven by induction motors. Raw water with compressed air agitation is used.

The plant equipment includes two 40-ton compressors, each driven by a 125-hp. 4000-v. induction motor of the slip-ring wound-rotor type; two 2½-in. brine pumps, each driven by a 3-hp. motor; two 7½-hp. vertical motors driving brine agitators; a 3-hp. motor driving an air compressor and a 7½-hp. motor driving a blower.

The storage rooms, which have a capacity of 3700 tons, are filled early in the season in the customary manner. Should one unit be out of service, the other could be forced to deliver 60 tons a day. When both machines are running, and the plant output is 60 tons a day, the kilowatt-hours per ton range from 43 to 50. During one summer month, when the average output was 60 tons a day, the average consumption was 45 kw.-hr. a ton.

Power is purchased from the local central station at 4000 v. for the two induction motors and at 220 v. 3-wire for other motors and lighting.



MOTOR-DRIVEN COMPRESSORS IN PLANT OF THE DULUTH ICE CO.

The Lettgo Mechanical Overload Release

THE above name immediately conveys to the reader the nature of the device to be described. Many classes of machinery offer variations in load to the driving motor, or source of power. These variations take different forms, and according to their nature, must be dealt with differently. For instance, a gradual increase and decrease within the capacity of the driving motor, or the driving mechanism, is best taken care of by a suitable governing device for controlling the power. Sharp transient irregularities, in the nature of jars, or shocks, are sometimes met by interposing a yielding device, such as a friction clutch between the driving and the driven parts; but an excessive or overload which obstructs the machine, or the driven parts, such remedial means is inadequate to prevent serious damage, and better means should be provided.

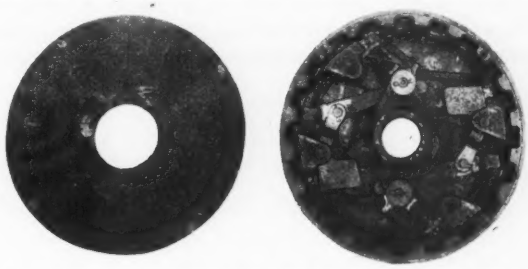


FIG. 1. VIEW OF WORKING PARTS OF THE LETTGO RELEASE

With motor driven machinery the circuit breaker is usually depended upon to act as a safety element to prevent overloading the motor, but it is a well known fact that it cannot always be depended upon. Even though the circuit breaker or overload fuse does separate in case of an overload, the inertia of the moving parts must be overcome.

The well known shear pin is universally used to disconnect the driving power from the driven machinery when the load, from any cause whatsoever, becomes excessive. It is also well known that after a shear pin has sheared off a number of times, a stronger or larger pin will invariably be used, and it will not have the proper safety factor, and disastrous and expensive wrecks will invariably result.

The above experience with the shear pin for safety led to the development of the Lettgo mechanical overload release, which, as the name implies, is a device which will automatically disengage the driving power from the driven machinery, if the load exceeds a predetermined amount, thus allowing the driving motor or source of power to run free without friction in the release.

The Lettgo release will take care of an overload gradually applied, as well as an overload suddenly ap-

plied, it can also be set so that it will not trip out with sudden jars or shocks, such as received in a crusher or shearing machine, in fact it has an unlimited field of applications.

The release can be installed close to the driving machinery so that when it does let go there is no inertia from high speed moving parts to be overcome to prevent damage. It is made symmetrical, and can be assembled

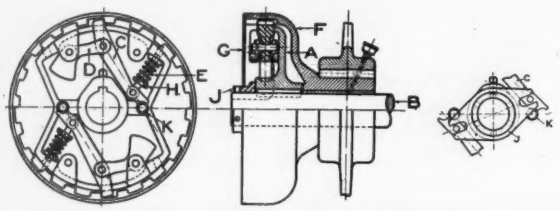


FIG. 2. CROSS SECTIONS OF LETTGO RELEASE

to operate in either direction. The springs have a means of adjusting the tension so that the release will operate at the proper load. With this release the proper factor of safety is always maintained, no matter how often it operates.

The photograph shows the Lettgo mechanical overload release as built to be applied to the driving gears of a typical endless chain bucket conveyor installation for handling coal in power house.

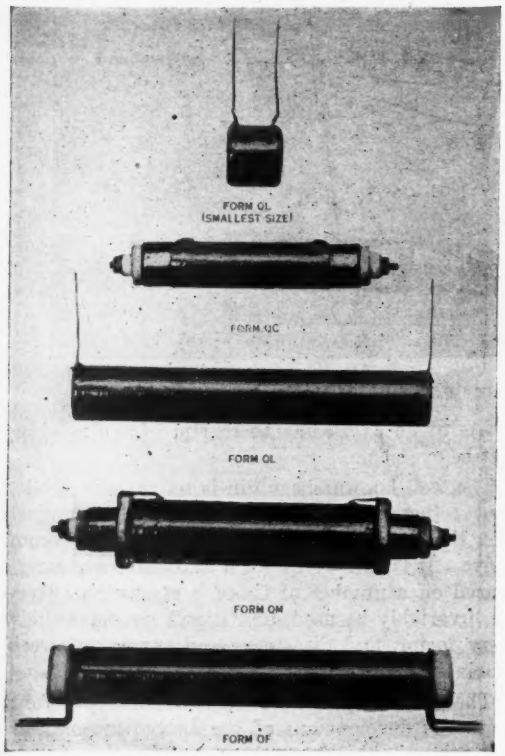


FIG. 1. TYPICAL ENAMELED RESISTOR UNITS

In the illustration, Fig. 2, the spider A keyed to the shaft B has triggers C pivotally mounted on link D with the ends engaging inside notches in the rim of the drum F and roller K in the spider A springs E, regulated to any desired pressure by the adjusting nuts H hold ends of triggers on roller K under normal conditions; but when the drive is overstrained the compression of the springs will permit the ends of trigger to drop into position shown in the detail sketch, releasing connection with the rim F and allowing the driven machinery to stop immediately.

To set the driving triggers in the driving position again, the collar J is provided, having fingers which engage pins on lower ends of triggers C. By turning this collar by means of a spanner wrench, the triggers will be moved to the original position, and the outer ends will at the same time enter notches in the drum F, thus renewing the transmission connection.

Cover G fitting end of drum F encloses and protects the entire mechanism. Hub of drum F may be extended to receive wheel or gear, and have a bushing for running loose on the shaft, or may be keyed directly to a separate shaft, thus forming a coupling device, in which either element may be the driver, according to the circumstances.

The mechanism in the release is entirely enclosed so that it can be packed with grease, insuring perfect lubrication for all operating parts. The single trigger release has been developed for reversible operation, arranged automatically to reset the driving trigger after being tripped out, if the direction of rotation is reversed. This device in all its various forms has been patented by Frank E. Aurand.

Enameled Resistance Units for Current Regulation

ENAMELED resistance units for regulating current have been developed. Some of the applications to which these units have been put are railway and fire alarm signals, fractional horsepower motors and locomotive headlights. They are also used exten-

FIG. 2. HEADLIGHT DIMMING RESISTOR WITH COVER REMOVED

sively in series with relay, contactor and circuit breaker coils on panels and switchboards. They will be found particularly applicable in mines and similar places where a great amount of dampness and moisture are present. These units are unique in their ability to withstand unusually high temperatures as well as sudden changes in temperature from one extreme to the other.

The resistance wire or conductor is wound either upon a steel body coated with a special refractory enamel or paint and high heat resisting silicate compound developed to withstand sudden extreme temperature changes without cracking or weakening or in any way being injured. The steel body is preferred for extreme lengths where strength for a long span is required, and is especially serviceable where the unit might be subjected to severe vibration or shock.

The refractory silicate body is used for most of the ordinary types of resistance. The compound employed is far superior to porcelain or any equivalent ceramic products which are easily cracked or weakened mechanically by repeated and extreme temperature fluctuations.

After being wound upon the proper body, the conductor is embedded in a blue vitreous enamel and is fused until it has a uniform glossy structure, at a temperature of about 1000 deg. C. This enamel is moisture and heat resisting and forms a mechanically strong casing for the conductor.

Several different methods of attachment to the circuit have been developed as shown in the accompanying illustration. A variety of units of various sizes and ohmic capacities have been standardized and units of a special nature are obtainable.

Transfer Relays

PROTECTIVE relays that operate by closing a separate direct-current tripping circuit which in turn trips the circuit-breaker, have proved more serviceable than "shunt-trip" relays and have come into very general use. In some cases, however, a separate direct-current tripping circuit is not available and other means must be sought. The use of "transfer" relays is the best solution so far obtained, for they energize the trip coil of the circuit-breaker through current transformers.

The breaker operates solely through the current transformer and the relays. When there is no fault on the line, the trip coil of the breaker is mechanically and electrically isolated from the circuit, avoiding possibility of tripping due to imperfection in the relay contacts ordinarily shunting the trip coil.

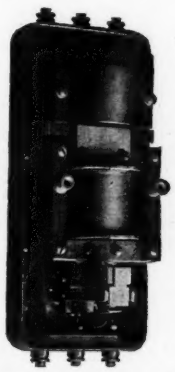


FIG. 1. TRANSFER RELAY, COVER REMOVED

The relay contains two series coils, an upper or operating coil and a lower or holding coil. The holding coil holds down the armature core, until a third coil, wound on the same magnetic circuit and known as the releasing coil, is short-circuited by the protective relay. The releasing coil acts as the secondary of a transformer and when short-circuited, a current flows through it, demagnetizing the core. The holding coil, therefore, allows the operating coil to raise the core which operates the transfer switch, thus closing the trip coil circuit.

The transfer switch and other current carrying parts of the relay are designed to carry 5 amp. continuously, but during times of short circuit the switch may be called on to handle as much as 100 or 200 amp.

A current transformer must be selected of sufficient capacity to operate the protective relay, the transfer relay, and the trip coil. Low-ratio bushing-type current transformers sometimes used on high-voltage circuit-breakers are not suitable.

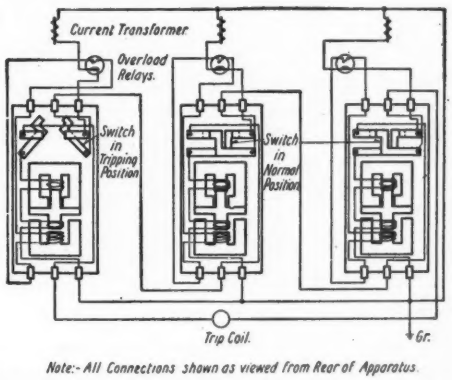


FIG. 2. DIAGRAM OF CONNECTIONS, TRANSFER RELAY, ONE THREE-PHASE ALTERNATING CURRENT CIRCUIT

Only one trip coil is required for use on a polyphase circuit, but if the breaker is equipped with as many trip coils as there are relays, it is advisable to connect each trip coil to its corresponding relay.

New Form of Variable Electrical Resistance

A RECENT German patent taken out by L. Strasser relates to a modification of the type of electrical resistance in which an iron wire enclosed in hydrogen is surrounded by a heating coil. As is well known, a small change in the current flowing through the heating coil can be made to cause a very considerable change of resistance in the iron, and such resistances are claimed to have special applications for use with machines of very variable speed. The novelty embodied in the patent consists in making the heating coil of a material which has a negative temperature coefficient. In this way the coil can be made to bring about a much greater change in the iron wire resistance, and the sensitiveness of the apparatus is accordingly increased.

THE QUANTITIES of pulverized coal used in the United States annually in various manufactures are as follows: In the cement industry, 6,000,000 tons; in the steel and iron industry, 2,000,000 tons; in the production of copper, 1,500,000 tons, and in the generation of power, 100,000 to 200,000 tons. To attain success the coal must be dried, crushed and pulverized until 95 per cent will pass through a 100-mesh sieve, having 10,000 openings to the square inch. A cubic inch will contain over 200,000,000 particles, none of which will be greater than one-hundredth of an inch cube, and a large percentage less than one six-hundredth of an inch cube.—COMPRESSED AIR MAGAZINE.

News Notes

On June 1 A. J. Kehoe joined The Ohio Brass Co. as salesman in the central territory. On the same date P. A. Green took up his duties as assistant sales agent in the home office.

W. G. Balph has been appointed manager of the safety switch section of the Westinghouse Krantz Factory, Brooklyn, N. Y. Prior to working as salesman in the New York office Mr. Balph was head of the fan motor division with offices at East Pittsburgh, Pa.

With the recent incorporation of the Betson Plastic Fire Brick Co., Frank J. Jewell was elected president and secretary, and Nelson Adams, vice-president and treasurer. The new corporation name is the Betson Plastic Fire Brick Co., Inc., Rome, N. Y.

F. V. Sargent has been appointed by the Chicago Pneumatic Tool Co. district manager of sales in the Boston territory, succeeding F. S. Eggleston, with headquarters at 182 High St., Boston, Mass.

E. A. Hitchcock has recently become connected with the Bailey Meter Co., of Cleveland, Ohio, as vice-president. He will supervise the training of technical graduates for the company's service and sales departments. During the past 6 yr. he has been connected with the E. W. Clark & Co. Management Corporation as advisory, consulting and power sales engineer. Previous to that time, he was Professor of Experimental Engineering at Ohio State University.

Wm. B. Scaife & Sons Co., of Pittsburgh, announces the opening, on July 1, of a Chicago sales and engineering office at 38 South Dearborn St., with Charles F. O'Hagan, formerly chief engineer of the company at Pittsburgh, as resident engineer and manager.

This company is stated to be the oldest manufacturing concern west of the Allegheny Mountains. During the more than one hundred years since their business was founded, they have from time to time, as conditions arose, added to their manufacturing facilities.

The Surplus Property Division of the War Department is offering for sale f.o.b. warehouse, Norfolk, Va., 912 tons of galvanized barbed wire and 4161 tons of black painted barbed wire. This is 12-gage, 4-point, and 3 in. between barbs and point, on spools approximately 58 lb. each.

No bid will be considered for less than 200 spools. Details may be obtained by writing to the zone supply officer, Zone 7, 1819 West 39th St., Chicago.

Fred B. Grosse has been released from service in the Army, having served 20 mo. overseas with the 77th Division, and is back at his job as advertising manager of the Plant Engineering & Equipment Co. at its new offices, 192 Broadway, New York City.

A branch office has been opened by the company in Cox Building, Atlanta, Ga., to take care of business in the states of South Carolina, Georgia and Florida, with John A. Culver manager.

Metallo Gasket Co. has recently been incorporated at New Brunswick, N. J.

The officers of the company are: Zeno Schultes, president and treasurer; Geo. Geipel, vice president; Stanley S. Geipel, secretary.

Zeno Schultes was manager of the Goetze Gasket & Packing Co. for about 15 yr. George Geipel has been an erecting engineer for some 35 yr., specializing in refrigerating and steam power plants, and Stanley S. Geipel has had 10 yr. experience in mechanical engineering.

H. L. Garbutt, for the last six years manager of the line material section of the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., has been appointed manager of the supply division of the Westinghouse San Francisco office. In 1908 Mr. Garbutt became a part of the sales organization of the Drew Electric & Mfg. Co., of Indianapolis, handling various types of overhead line material, with which company he remained until 1909, when he entered the supply department of the Chicago office of the Westinghouse Co., as line material specialist, in which position he served until 1913, when he was made manager of the line material section, with offices at East Pittsburgh, Pa., serving in the capacity of manager until his recent promotion.

S. F. Bowser Co., Ltd., Toronto, Ont., has recently reorganized to operate as a strictly Canadian organization, financed and managed under Canadian control. The Canadian business of the company has grown steadily from year to year, practically its entire Canadian trade being supplied from the Toronto factory. Believing thoroughly in and being enthusiastic about the future of Canada, this company decided recently to organize, under the Canadian laws, as a strictly Canadian firm, putting the management into the hands of the present efficient sales manager, H. C. Christie, with E. E. Cummings as factory manager. The other officers are: S. F. Bowser, president; S. B. Bechtel, vice-president; H. J. Grosvenor, secretary; W. G. Zahrt, treasurer.

U. S. Civil Service Commission announces an examination, July 23-24, Aug. 20-21 and Sept. 17-18, for laboratory assistant, for men only. Vacancies at the U. S. Navy Yard, Washington, D. C., at entrance salaries ranging from $4.48 to $5.92 a day, depending on qualifications of appointees, and in positions requiring similar qualifications, will be filled from this examination. Competitors will be examined in the following subjects, which will have the relative weights indicated: General physics, 25; practical questions on each optional subject chosen, 40; education, training and experience, 35. The applicant must show that he has graduated from a 4-yr. course in a college or university of recognized standing or that he is a senior student in such an institution and expects to graduate within 6 mo. from the date of the examination, and must have reached his twentieth but not his thirty-fifth birthday on the date of the examination. Apply for Form 1312.

Catalog No. 258 of The Jeffrey Manufacturing Co. is now ready for distribution. It contains 75 pages devoted to installations of conveyors in various industries, specifications, general dimensions and other important data of vital interest. This catalog will be of special advantage as it will save the time and expense heretofore required in making drawings and layouts for particular needs.